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सत्यमेव जयते

Report On

IMPACT OF CHANGING AGRICULTURAL PRACTICES ON RURAL HEALTH: A STUDY AMONG THE TRIBAL FARMERS OF VIDARBHA REGION OF MAHARASHTRA

2024 - 25

ANTHROPOLOGICAL SURVEY OF INDIA
CENTRAL REGIONAL CENTRE
GOVT. OF INDIA
MINISTRY OF CULTURE
NAGPUR, MAHARASHTRA

PRINCIPAL ADVISORS

Prof. B.V. Sharma
Director
Anthropological Survey of India, Kolkata

Prof. Ramdas Dattatray Gambhir (Retd.)
Department of Anthropology
University of Pune

Prof. Kanhu Charan Satapathy
Department of Anthropology
Utkal University, Odisha

PRINCIPAL INVESTIGATORS

Subhra Sankha Barik, Superintending Anthropologist (Phy.)
Dr. Abhishikta Ghosh Roy, Superintending Anthropologist (Phy.)

PRINCIPAL COORDINATOR

Reddy Narasimhan Naidu, Asst. Anthropologist (Phy.)

RESEARCH INVESTIGATORS

Reddy Narasimham Naidu, Asst. Anthropologist (Phy.), CRC
Sanjay Gajbiye, Research Associate (Bio-Chem.), SRC
Kiran Uttarvalli, Research Associate (Phy.), CRC
Joy Das, Research Associate (Bio-Chem.), CRC
Pranjali Ramteke, Research Associate (Cul.), Sub RC
Ganesh Chandru Ramteke, Research Associate (Phy.), NWRC
Anjali S. Nikam, Research Associate (Phy.), NWRC
Priya Dey, Junior Research Fellow, CRC
Mukti Singhai, Junior Research Fellow, CRC

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Research Team

Anthropological Survey of India,

Central Regional Centre, Nagpur

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CHAPTER 1
INTRODUCTION

About 12000 years ago, modern human species brought a revolution in civilization, through initiation of agricultural practices on the planet earth. We, the *Homo sapiens sapiens* is being depending on agriculture in different forms since pre-historic period but never could discard it from our livelihood strategies, even today. Agriculture is our primary source for sustenance,playing a key role in providing food security to ever growing population. Modern mechanized agricultural systems, despite generating negative impacts on some fronts, still supply global markets with large volumes of food and have boasted breakthroughs in crop productivity, food processing, distribution, and improvements in food safety (Frison, 2016). Being an agricultural state, India has witnessed a phenomenal transformation in its agricultural sector since independence. The Green Revolution (in mid-1960s), the Yellow Revolution (in the early 1990s), Gene Revolution (in early 2000s) and the Pulse Revolution (in the 2010s) were the landmarks of changing scenario of Indian agricultural sector in emerging India as world's largest producer of pulses, pearl millet and cotton, and second best in wheat, rice, groundnut, rapeseed, mustard, and sugarcane. Intensified crop cultivation, irrigation management, induction of high-yielding seed varieties, application of chemical fertilizers and insecticides, rotation of crop cycles has played immense contribution in transforming India from a crop growing nation to a crop exporting nation.

Agriculture contributed 18.3 % Gross Value Added (GVA) to India's economy in 2022-23, as reported by the Ministry of Agriculture and Farmers' Welfare. Additionally, it supports India's foreign trade, contributing $50 billion to exports in 2022-23, or approximately 13% of the country's total exports. Moreover 45 % of India's workforce engaged in agriculture and allied activities, the sector remains a potential source of livelihoods, particularly in rural areas (https://agrinextcon.com/the-economic-impact-of-agriculture-on-indias-gdp/). Apart from high-yielding crop varieties and other facilitative measures for massive crop productions, there has remarkable changes in the cropping patterns in India over years. Maximum area of crop fields in India before the Green Revolution either was occupied with monoculture food grains or seasonal vegetables with least diversification, Entire scenario has changed post Green Revolution era with introduction of the minimum support price (MSP) and other government subsidies had influenced farmers' choice largely towards producing food grains like paddy (as major *kharif* crop) and wheat (as major *rabi* crop). However, advent of economic reforms in early 90s had opened Indian domestic agriculture produces to the global markets, thus had created further opportunities for agricultural exports leading to significant diversification in cropping patterns toward non-food crops.

Main feature of agricultural practices in India was that earlier farmers primarily focused on producing crops almost entirely for subsistence. Later, these practices transformed to a subsidy-based purely focusing on production of different varieties of cash crops rather than tilling land for growing traditional food grains in traditional way, across the nation. Inevitably, substantial transformation in agricultural production from subsistence food grains to non-food cash crops has simultaneously emerged several environmental as well as health challenges as consequences. The Green Revolution, which brought high-yielding varieties of crop and chemical-based farming helped in achieving in food sufficiency with boomed crop production, thus also led to overdependence on chemical fertilizers and pesticides rather our age-old traditional procedures, due to declining soil fertility over years and invasive pestes infestations in crop fields. Such changes have exacerbated by neoliberal policies that have led to the corporatization of agriculture fields, as economically viable agricultural industries (Patnaik, 2010; Lerche, 2013). Chaning agricultural practices is due to shift towards intensified of cultivation practices have not only impact on agricultural economy of the but also also raise concerns about the potential impact on the human health as well as on overall environment of rural settings elsewhere.

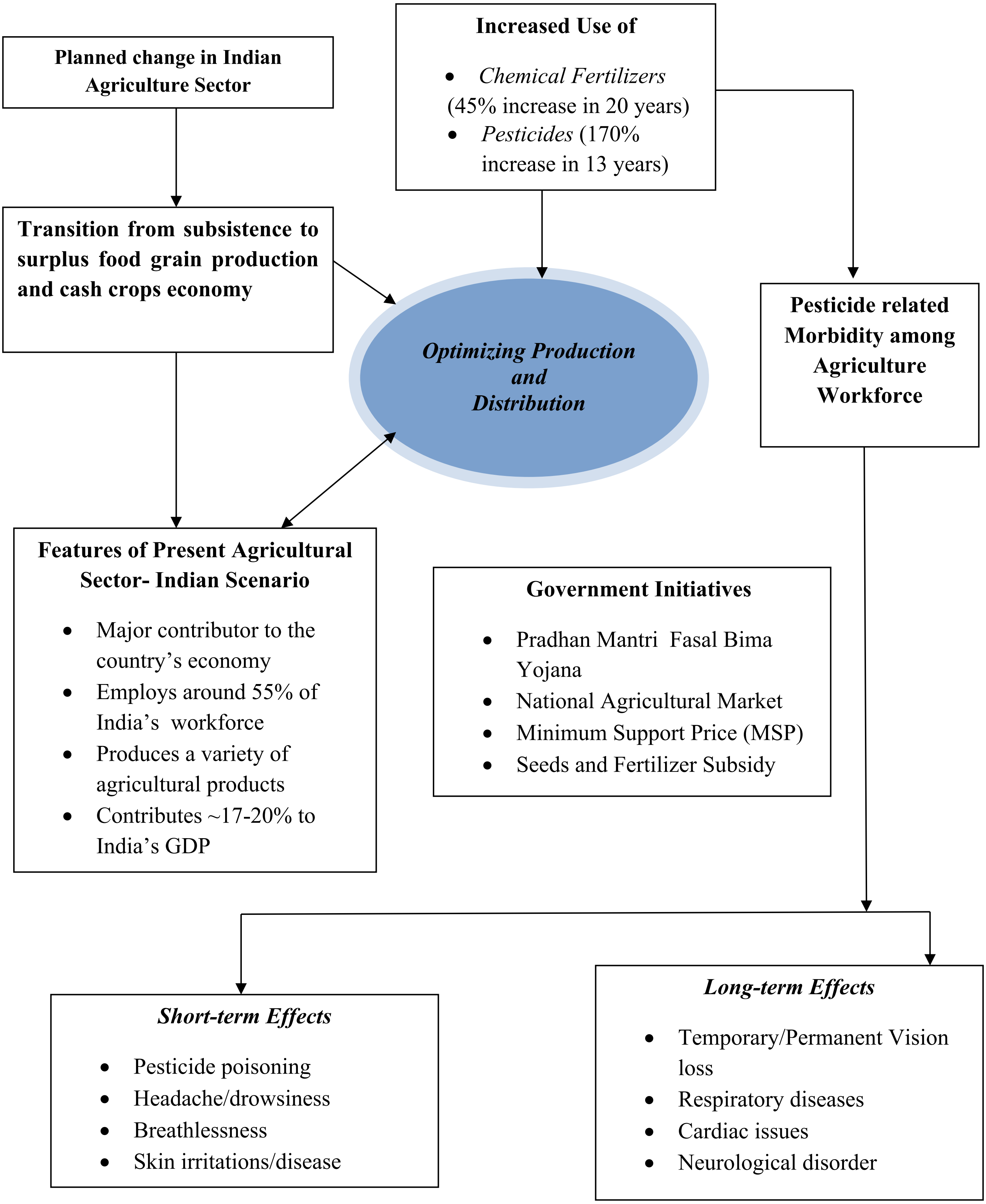
The Vidharbh region of Maharashtra, no longer remains far away from intensified agricultural practices in response to the times. This region has also been experiencing significant changes in agricultural sector during last few decades. Traditional multi-crop cultivation practices have rapidly replaced by cash crop cultivation - especially cotton and soybean is now has became the primary crop, throughout the region (Cotton Corporation of India, 2021; Directorate of Economics and Statistics, Maharashtra, 2021). The Cotton Corporation of India (2021), reports that genetically modified cotton seeds, in the form of Vidarbha, an area known as the cotton-growing belt, shows exponential growth. This has also enhanced the dependence of agro chemicals. Furthermore, the data presented by Maharashtra State Agriculture Department in 2021 highlighted the tendencies of mono-culture cropping, biodiversity loss, and soil degradation. Transition in agricultural practices has resulted in a decline of crop diversity in Vidarbha region. Rao *et al.* (2018) noted that crop diversity had declined by 30% from 1990 and 2015. Shannon's Index, (crop diversity index) has declined from 1.8 in 1990 to 1.2 in 2015, highlighting the development of monocultures (Wagh and Dongre, 2016). Since the 1990s, the Vidarbha region has been experiencing intensive farming patterns in many ways. Kulkarni *et al.* (2018) noted that the use of tractors and power tillers in the Vidarbha region had surged up to 150 % from 2000 and 2015. Bhople and Borkar (2016) highlighted that cotton planting density increased from 11,000 plants per hectare to more than 55,000 plants per hectare of land in certain areas between 1990 and 2010. Ramteke et al. (2019) observed a substantial decline in fallow periods from six months to less than two months between 1980 and 2015.

Besides shifting of technologies, Vidarbh's agricultural fields are also simultaneously exposed to different kinds of chemicals, either in the form of fertilizers for bumper production or pesticides or herbicides for crop protection. Reddy *et al.*, (2020) reported that fertilizer use increased by 45% from 2000 to 2020 in this region. The Maharashtra State Agriculture Department (2021) spotted a major change in urea use as fertilizer in crop fields over the last twenty years. Amount increased from 382,000 tonnes of urea in 2000-2001 to 687,000 tonnes in 2019-2020. In addition to composite fertilizer ratio of Nitrogen (N), Phosphorous (P) and Potassium (K) also increased from 4:2:1 in 1990 had increased to an imbalanced ratio of 8:3:1 by 2015 (Mhaske *et al.*, 2017). Furthermore, uncontrolled using of fertilizers in agricultural fields, application of pesticide has also surged high in the Vidarbha region. Kranthi *et al.* (2014) reported that the pesticide uses in the cotton growing areas of Vidarbha increased by 170% during the period 2000 and 2013. Organophosphates, pyrethroids and neonicotinoids are primary pesticides in using in this region (Deshmukh *et al.*, 2015). The Maharashtra Pollution Control Board (2021) reported that annual pesticide use in Vidarbha had upsurged from 2,100 metric tonnes in 2000 to 5,600 metric tonnes in 2020.

Pesticides are largely insecticides, herbicides, and fungicides to prevent crops from harmful living organisms in crop fields. Globally, there are several studies on health hazards among farmers because of use of application of pesticides. A study among the farmer communities revealed that headache, excessive sweating, thirst, and weakness were very common symptoms experienced by them (Hossain M.E., *et al.* 2012). Another study revealed that higher level of urinary metabolites of organophosphates and pyrethroids were reported in Thai children living on a rice farm (Fiedler *et al.* 2015). Human blood is commonly used as a pesticide bio-monitoring matrix because it allows for direct measurement of intact compounds. Oxidative stress, DNA damage and genetic risks due to pesticides can be easily monitored through blood (Remor *et al.* 2009). Higher level of DNA damage has been reported in workers who have higher concentrations of pesticide residue in their blood (Ali *et al.* 2006; Bhalli *et al.* 2006a, b). A study conducted among the Marmara region of Turkey, reported that the use of increasingly large quantities of agricultural chemicals causes contamination of both agricultural and surrounding areas and this contamination affects people living in this region (Berg 2001). Simultaneously in some other studies, using of pesticides reported elevated risk in ovarian cancer (Ammons, S. *et al.* 2025), lung diseases (Ezennia, S.C. *et al.* 2025), cancer risk among male farmers (Hurwitz, L.M. *et al.*2025). In India, gradual increasing application of pesticides and chemical fertilizers has raised concerns over it's impact on public health in rural India. Several studies on impacts on public health due to excess use of fertilizers and pesticides in crop fields have already reported various health issues. Those are leading to an array of health outcomes, including cancer, diabetes, and respiratory, neurodegenerative, cardiovascular, reproductive, and genetic disorders (Sanborn *et al.* 2007; Remor *et al.* 2009; Perumalla Venkata *et al.* 2016). Nature and severity of the hazard can vary depending on the chemical composition of pesticide, dose, route of exposure (i.e., oral, dermal, or inhalation), and duration of exposure (Hernandez *et al.* 2013). Prolonged exposure has linked to a range of adverse health outcomes among the farming communities of rural India. Occupational exposure has been mostly studied in farm-workers and its association with diseases such as cancer, neurological pathologies, and the effects on fertility and pregnancy (Dahiri, B *et al.* 2021).

Anupama *et al.* (2014) reported that the CKD prevalence rate varies from 2.5-3.8% in rural Maharashtra, which includes parts of Vidarbh. A recent cross-sectional study by Jawale *et al.* (2020) across rural Vidarbha reported a much higher CKD prevalence rate of 4.3% (95% CI: 3.7-4.9%). Annual incidence rate of CKD was reported to be 198 per 100,000 populations in a 5-year prospective study in eastern Vidarbha (Deshpande *et al.*, 2018). Khandelwal *et al.* (2016) reported that diabetic nephropathy represented around 38% of CKD cases in their study population. Incidence of diabetes among the rural people of Vidarbha has also risen from 2.2% in 2000 to 7.9% in 2019 (Chandanshive *et al.*, 2020) and may be responsible for rising rates of CKD. Hypertension is another significant factor to CKD in this region. Patil *et al.* (2019) observed that 29% of CKD cases in their study were associated with hypertensive nephropathy. The prevalence of rural hypertension in Vidarbha increased from 15.2% in the year 2005 to 23.6% during 2018 (Deshmukh *et al.*, 2021). Studies by Deshpande *et al.* 2018; Jawale *et al.* 2020 repoted respiratory diseases, and neurological

Fig.1 Sustained Use of Agro-chemicals – Health Impacts on Tribal Farmers



disorders because of repeated exposure to agro chemicals, mostly without protection, has hugely increased the potential for pesticide poisoning among farmers.

This has not only had impacts on agricultural productivity but also serious concerns regarding human health. The region has also faced an upward trend in farmer suicides driven by financial distress (Kennedy and King, 2014; Mishra, 2014) and health-related challenges arising from pesticide exposure and economic vulnerability (Bomble and Lhungdim, 2020). Pesticide exposure has been linked to various health issues among farmers in Vidarbh. In 2017, more than 40 cotton farmers and farm labourers died in Vidarbha, with 21 deaths in the Yavatmal district alone, reportedly due to pesticide poisoning (Mint, 2017). A joint survey by ICAR and the Central Institute of Cotton Research (CICR), Nagpur, found that most of the poisoning cases were associated with the use of insecticides like monocrotophos, profenophos, cypermethrin, fipronil, imidacloprid, and diafenthiuron (Mint, 2017).

In addition to different types of chronic diseases and adult deaths, Vidarbha region also witnesses concerning trends in mortality rates. The infant mortality rate (IMR) in Vidarbha (overall varies from 35 to 40 per 1,000 live births: NFHS-5: 2019-2021) is reported to be higher than the national average (27.59 /1,000 live births in 2022), and the state average (16 per 1,000 live births in 2020). In the Yavatmal district, where cotton occupies a significant share of cash crop production, the IMR is about 30 to 35 per 1,000 live births (Sample Registration System Report, People's Archive of Rural India, 2020). Child mortality below 59 months was also reported to be about 77 per 1,000 live births in Yavatmal (Indirect Estimates of District-wise IMR and Under-5 Mortality using Census 2011 data - Draft/NHSRC). Bang *et al.* (2002) noted a neo-natal death rate of 50.5 per 1,000 live births, an IMR of 67.3 per 1,000 live births, and an under-5 child mortality rate of 91.3 per 1,000 live births in the Yavatmal district during 1998-2000. Ashwani *et al.* (2023) stated that Vidarbh's average regional infant mortality rate is 31.72 per 1,000 live births. According to location quotient bifurcation, Buldana, Yavatmal, Washim, Wardha, and Bhandara are high, while Akola, Amravati, and Gadchiroli have under-medium infant mortality rates. The study also reported that the Vidarbha region has the highest infant mortality rate among all districts in Maharashtra, which is also known for its high incidence of farmer suicides.

SIGNIFICANCE OF THE STUDY

Since in depth studies on mortality and morbidity with reasonably large samples and more specifically with a focus on changing trends in the agricultural practices and its associated effects are not available, the hypothesis needs to be tested though more comprehensive epidemiological research.

The impact of intensified agricultural practices and the other associated agricultural innovations on the health and disease of the tribal farmers of Vidarbha region of Maharastra is valuable as the socio-economic and cultural correlates in this study would be unique. A thematic diagramme of impact of sustained use of various agro chemicals on tribal farmers' health is presented to narrate the significant of this study (Fig.1).

OBJECTIVES

The proposed study aims to explore the epidemiological assessment of the impact of intensified agricultural practices among the tribal farmers of the Vidarbha region of Maharashtra.

1. To gain insight into the current socio-economic conditions of the farmers at the household level.
2. To understand the changes in agricultural practices in the last few decades and establish the current cultivation practices with specific reference to use of fertilizers, pesticides, mechanization etc.
3. To understand the health consequences of changes in lifestyle in general and food cultures in particular those were more specifically attributed to the changed agricultural practices, and changes in socio-economic and political institutions of studied communities.
4. To study the health status including the reproductive health of tribal farming communities through comprehensive mortality and morbidity survey along with the perceived disease aetiologies.
5. To understand the health and illness behaviours of the tribal farmers.

HYPOTHESIS

Shifting from traditional mono-crop cultivation to highly intensified cash crop cultivation practices in the Yavatmal district (Vidarbha region) over times, presumably have brought some significant changes in the socio-economic institutions of tribal societies simultaneous to disease patterns in villages, thus need to be testified through an extensive as well as an intensive household survey among tribal farmers of this area.

METHODOLOGY

Research Gap

Research gap related to changing agricultural practices and health burdens in the Vidarbha region are evident across various studies, highlighting critical aspects yet to be fully explored. While studies do indicate that health problems have arisen because of changes in agricultural practices, particularly among farmers (such as mono-cropping and increased use of pesticides), the studies on the overall morbidity burden are not adequate. Further, dearth of studies focusing on tribal farmers is evident.

Research indicates a rise in long-term medical disorders such as kidney disease (possibly chronic kidney disease of unknown etiology) and respiratory issues. There is, however, a dearth of detailed scientific linking specific farming practices to long-term health effects and the differential impacts of such practices on members of different socio-economic groups, sexes and age groups. In a study on chronic kidney diseases in the region, re-evaluation, and in-depth analysis of how soil and water quality contribute to these conditions is highlighted as necessary (Bawaskar, 2020). Studies that covered aspects of general changes in lifestyle, food cultures and agricultural practices with shifts to intensified agricultural practices too perhaps add value as it will inform on the sources of food and water currently for the tribal farmers.

Tribal farmers who have been pushed to adopt the agricultural innovations without sufficient knowledge of preventive behaviour face the risk of higher morbidity. The study of the extent of disease burden among the tribal farmers in Vidharba is thus valuable as not only their educational levels are poor, but also their preventive behaviour are affected by values and attitudes; culture structure; motor patterns and superstitions. Further, the identification of factors responsible for the chronic diseases suffered by the tribal farmers under agent-host-environment framework (Mills, K.T. et. al., 2009, Dayton, S.B. et al., 2010 and Thelin, N. et. al., 2013) of the “Epidemiological Triad Model” would be more comprehensive approach to this study.

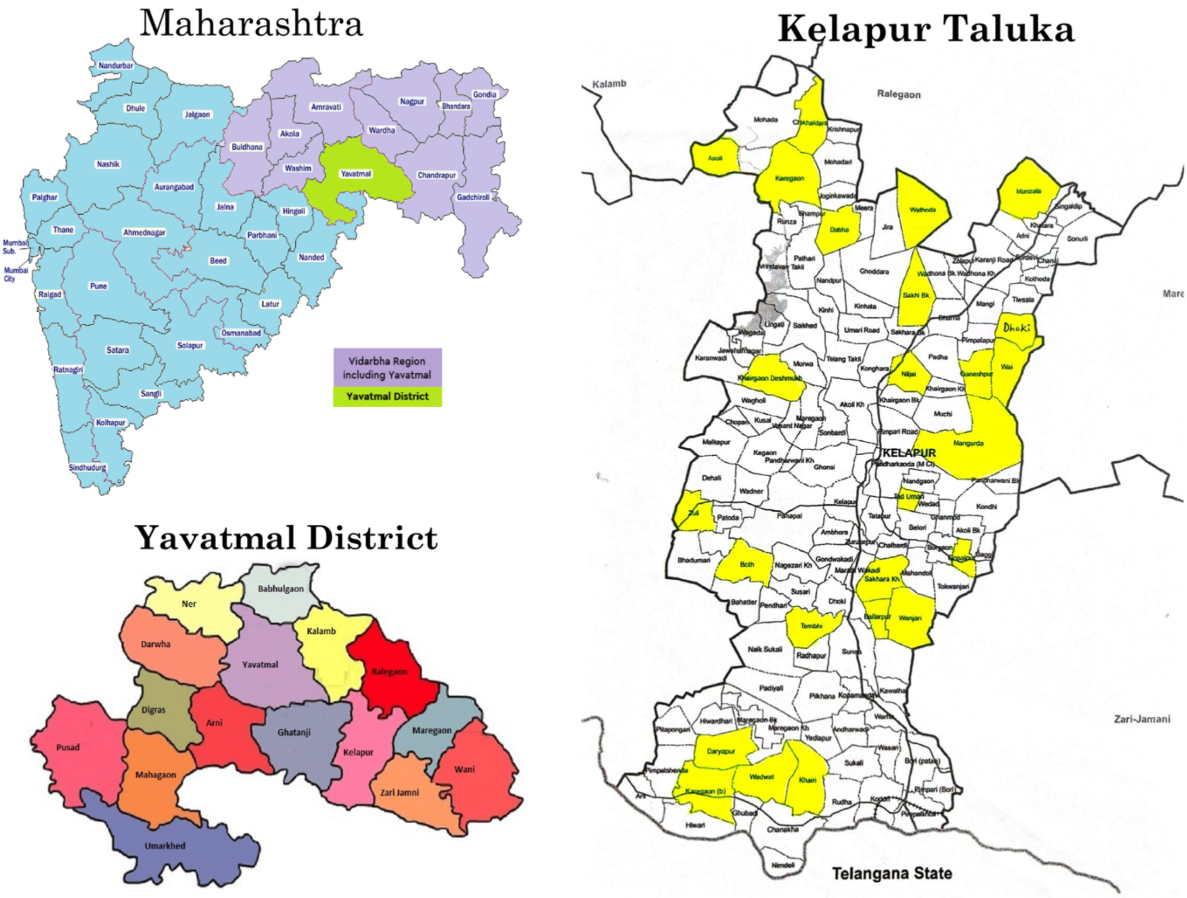
Studies on farmer suicides brought on by financial hardship are common, but there is still a dearth of information about mental health issues among other groups, such as women farmers. It is unclear how farming's psychosocial elements,such as social stigma, stress, and isolationare affected by evolving agricultural practices. Shidhaye et al. (2016) made a significant contribution by highlighting the need for more thorough epidemiological data on depression and mental health in rural communities. Agricultural yields are directly impacted by changes in climate patterns, contributing to the burden on the economy and public health. Though these are well-known challenges in the region, the efficiency of the adaptation measures farmers employ has not been thoroughly studied in Vidarbha. A recent study highlights adaptation strategies, yet their long-term effectiveness on health and financial resilience is still underexplored (Swami et al., 2022). In the studied region, female farmers frequently face exacerbated social and economic pressures, like as household duties and labour burdens. There are, however, few research, those looking explicitly at how women's health and social dynamics are impacted by altered agricultural techniques and economic hardship (Jadhav, 2019). The gaps reveal the need for more interdisciplinary studies addressing the health impacts of shifting agricultural practices, gender-specific burdens, and psychosocial health in Vidarbh.

Study Area

Vidarbha region is situated in the eastern part of the Indian state of Maharashtra and it is divided into two administrative divisions - Amravati Division (comprising districts of Amravati, Akola, Yavatmal, Buldhana and Washim) and Nagpur Division (comprising districts of Nagpur, Wardha, Bhandara, Gondia, Chandrapur and Gadchiroli). Telangana, Chhattisgarh, Madhya Pradesh and Andhra Pradesh are four states, which share a state boundary with the Vidarbha region. It is a drought prone region, where rain fed multi-crop cultivation practice is phenomenal in Vidarbha. Rice, wheat, sorghum (*jawar*), *tur* (pigeon pea), *chana* (black geam) are the primary food crops and cotton and soybean is the prominent cash crops in this region (Fig. 2).

Sample size and Sampling design

Fig. 2. The map illustrates the study area, with the surveyed villages of Kelapur Taluka highlighted in yellow



Yavatmal district is situated in the central Vidarbha region, beteen 20º39′92″ (N) and 78º11′79″ (E). Amravati district in the north, Parbhani and Akola district in the west, Adilabad and Nanded district in the south and in the east Chandrapur and Wardhs districts are sharing boundaries it Yavatmal district. This district categorised as Agricultural Zone – VIII, based on the annual rainfall receives. Out of 13,51,966 hectors of total geographical area of this disctrict, cultivable area occupies 71.04 % of the land-mass both with *kharip* and *rabi* crops. Altogether 4,17,402 persons are recorded under as farmers and about 45.49% are marginal to small farmers, while 54.51% are engage in large-scale farming activities (http://kvkyavatmal.pdkv.ac.in/?page_id=309). However, whatever the economic condition of the farmers, this district is known for it's intensive cotton cultivation, with induction of advance technologies and application of various kinds of agro-chemicals for bumper yields. Most of the farmers of the Yavatmal district rely on cotton farming for their livelihood (District Census

Handbook, Yavatmal, 2011). NHH-44, PKV-HY-2, Suraj Bt., Rajat Bt., Zordar, Malini, Nava Mallika, Private Hybrids are the most cultivated cotton varities in this district. The district has also witnessed an increase in adoption of Bt cotton varieties, to ensure increasing crop production.

Exploring agricultural patterns and their implications on public health in this district will help to provide an insight into the differential effects of intensified agricultural practices on the health and well-being of farmer communities. This study will try to understand the epidemiological implications of agricultural practices of Yavatmal with a view to understand the link between farming and public health in Vidarbh.

Accordingly, this study was conducted in the 25 villages of Kelapur Taluka of Yavatmal district. Kelapur Taluka has a considerable tribal population. As per the 2011 Census, the ST population in Yavatmal district is 5,14,057, which constitutes 18.54% of the total district population of 27,72,348. In Kelapur Taluka specifically, the ST population is 52,291, representing 41.61% of the taluka's total population of 1,25,689 persons.

Subject selection and method

An intensive fieldwork for a period of fifty days was carried out by the team of multi-discipline scholars of Anthropological Survey of India, during December, 2024 and January, 2025. Relevant data was collected through multi-stage cluster sampling. Primarily it was in two stages: Stage-1, was selection of the Blocks followed by selection of villages and Stage-2, was selection of households, from each selected village..

Kelapur Taluka comprises of 125 villages. For this study 25 villages was purposefully selected considering on the spatial diversity of tribal households and their concentration across the Taluka. The selection process ensured spatial heterogeneity and representation of tribal villages from different regions of the study area. While this selection provided geographic distribution, it was not stratified by eco-geographic (e.g., terrain, soil type) or agro-economic (e.g., cropping system, irrigation) criteria.

A random sample of 25 to 35 tribal farmer and agricultural worker households was considered from the selected villages, with at least 20% of the tribal households in each village. This percentage was sufficient to capture intra-village variation. Overall, 1,061 tribal homes were surveyed, accounting for approximately 20-25 percent of Kelapur Taluka's total tribal population of 4,601 individuals. The sample technique provides adequate statistical representation across Kelapur Taluka along with inter-village variation in agro-economic and health indicators.

Data collection Tools and Techniques

Both quantitative and qualitative techniques were used to cover the study objectives comprehensively. Duly structured household schedules were employed to obtain comprehensive data on socio-economic status, farming practices, health conditions and demographic profiles. Village profile schedules were also adopted to obtain community-level data on infrastructure, cropping patterns, availability of health services and environmental characteristics.

In addition to household survey, semi-structured interviews were also conducted among informants of relevance, such as health administrators, PHC staff, Agricultural Extension Officers, ASHAs and traditional healers. Those interviews provided contextual information on institutional views regarding health and agriculture. Furthermore, Focus Group Discussions (FGDs) were also conducted in every village involving tribal farmers, community elders and other stake holders of relevance.

Statistical Analysis

The study combined bivariate and multivariate statistical methods to examine the relationships between agricultural practices, agro-chemical exposure, and health outcomes, such as morbidity, mortality, and reproductive events, within farming households. The analytical framework followed standard epidemiological methods for assessing health risks in high-input agricultural systems, while being mindful of rural household contexts (Kirkwood & Sterne, 2003).

1. Bivariate Analysis:

Bivariate analyses assessed direct associations between exposure indicators and health outcomes. Chi-square (χ^2) tests examined the independence between categorical exposure variables, including cotton and soybean cultivation, landholding size, household proximity to agro-chemicals, and chemical storage practices, and outcomes related to morbidity, mortality, and reproductive loss (Agresti, 2018).

For ordinal exposure variables, especially landholding categories, Cochran–Armitage trend tests identified exposure–response gradients (Agresti, 2018). Crude odds ratios (ORs) with 95% confidence intervals estimated the strength and direction of associations (Kirkwood & Sterne, 2003). When relevant, sex-specific comparisons captured differential vulnerability.

Bivariate analyses also explored connections between parameters, including associations between cash-crop systems and chemical intensity, family structure and domestic exposure, and exposure indicators with specific morbidity categories, such as cardiovascular, renal, respiratory, and agro-chemical-related conditions (Agresti, 2018; Kirkwood & Sterne, 2003). Cause-specific mortality outcomes were examined through exposure–outcome cross-tabulations, while reproductive outcomes were assessed in relation to exposure history, accounting for age-at-conception bands to reduce life-course bias (Kirkwood & Sterne, 2003).

2. Multivariate Analysis:

To control for confounding factors and assess independent effects, multivariate statistical models were used. Binary logistic regression analyzed overall morbidity and specific morbidity categories, with exposure proxies—such as pesticide, herbicide, and weedicide use, cotton and soybean cultivation, and household proximity to agro-chemicals—alongside demographic factors like age, sex, household size, and family type (Kirkwood & Sterne, 2003).

Cause-specific mortality outcomes, including cardiovascular, cancer, renal, and unnatural deaths, were analyzed using Cox proportional hazards models when time-to-event data was available (Hosmer et al., 2008). Proportional hazards assumptions were checked using Schoenfeld residuals (Schoenfeld, 1982). In cases where survival data were incomplete, stratified logistic regression models distinguished between adult and elderly mortality patterns while accounting for village-level effects (Hosmer et al., 2008).

Reproductive outcomes were examined using multinomial logistic regression, differentiating between no adverse outcome, miscarriage, and stillbirth. Relative risk ratios (RRRs) were calculated across exposure categories, adjusting for maternal age and parity (Long & Freese, 2014). All multivariate models reported adjusted effect estimates with 95% confidence intervals and underwent standard diagnostic checks for model fit, multicollinearity, and discrimination (Kirkwood & Sterne, 2003).

3. Correlation Structure and Principal Component Analysis:

Correlation analysis and Principal Component Analysis (PCA) explored connections among agro-chemical exposure, health outcomes, and socio-demographic context (Jolliffe & Cadima, 2016). PCA was performed on thematic variable blocks covering exposure indicators, morbidity profiles, mortality composition, reproductive outcomes, and household socio-economic characteristics, treating factor loadings of ≥0.40 as meaningful (Jolliffe & Cadima, 2016).

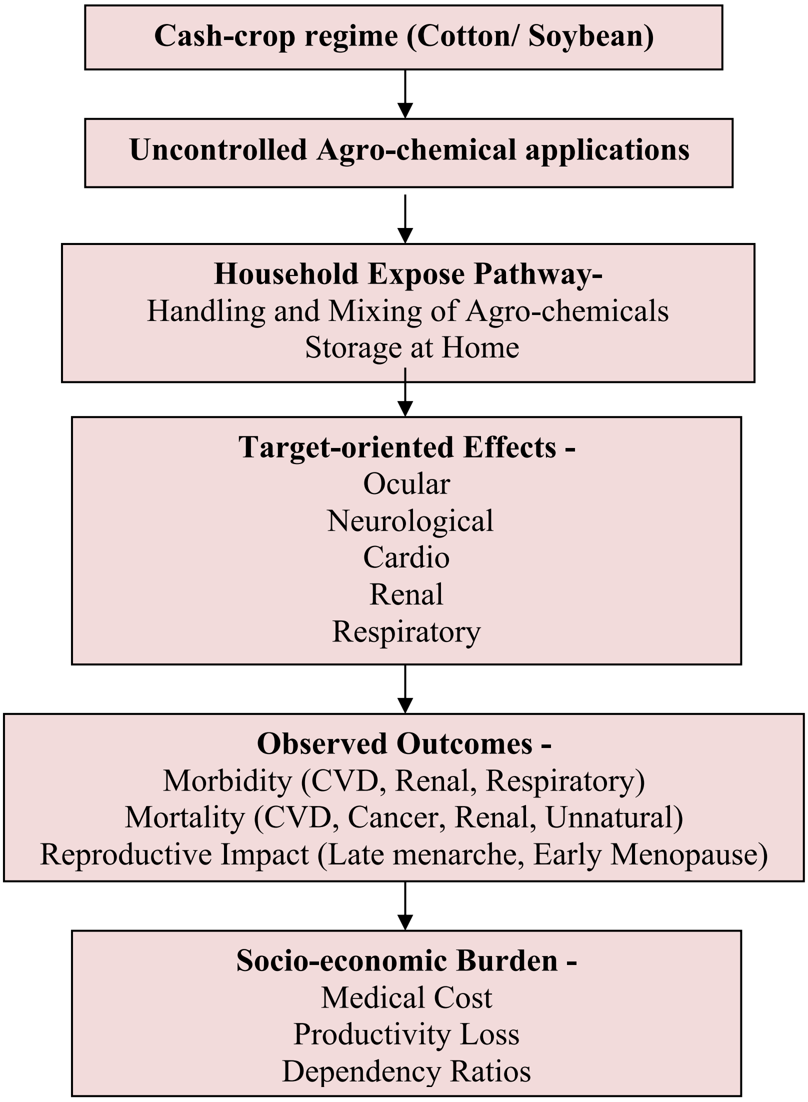
The first principal component was expected to capture clusters of exposure-related morbidity, while later components were anticipated to reflect demographic aging effects and occupational or economic stress, particularly among working-age households and those facing unnatural mortality (Jolliffe & Cadima, 2016). Correlation matrices and heatmaps visualized these patterns and were interpreted using standard effect-size benchmarks (Cohen, 1988).

4. Visualization and Synthesis:

Findings across different analytical stages were combined using various visual tools. Forest plots summarized effect estimates (ORs, HRs, and RRRs) with 95% confidence intervals, aiding comparison across exposure categories (Kirkwood & Sterne, 2003). PCA scatterplots illustrated household-level clustering by exposure intensity and health outcomes (Jolliffe & Cadima, 2016). Heatmaps highlighted the strongest exposure–outcome associations and were interpreted using standardized effect-size conventions (Cohen, 1988). Sankey diagrams traced links from socio-economic conditions to exposure pathways and health consequences.

5. Causal Pathway (Clean Flowchart):

The flowchart below summarizes the proposed pathway from cash-crop systems to exposure routes and target-organ effects, which lead to morbidity, mortality, and reproductive outcomes, ultimately resulting in socio-economic burdens.



6. Interpretive Integration (Bio-cultural Perspective):

Instead of adding new analyses, interpretation focused on a bio-cultural perspective that places statistical associations within everyday agricultural practices and household organization (Goodman & Leatherman, 1998). Observed patterns in morbidity, mortality, and reproductive outcomes were interpreted concerning landholding size, the dominance of cotton and soybean cultivation, household labor arrangements, and domestic handling and storage of agro chemicals (Goodman & Leatherman, 1998).

This integrative approach connects regression results, correlation structures, and PCA patterns to shared exposure pathways at both household and village levels. It emphasizes how occupational exposure, domestic proximity, and socio-demographic factors intersect to create clustered vulnerabilities in high-input agricultural systems (Goodman & Leatherman, 1998).

Ethnic composition

Farmers of those studied villages are multi-ethnic by nature. Altogether 1061 households of different ethnic background were covered in this study. Table 1.2. shows the ethnic composition of the Scheduled Tribe communities in the study villages of Kelapur tehsil (Yavatmal district) that presents a diverse distributionof six distinct tribal communities represented across 1061 surveyed households and comprising a total of 4604 individuals.

Table 1.2. Ethnic Composition (Scheduled Tribes) of the Study Area

Community	Household	Household (Percentage)	Estimated Individual	Individual (Percentage)
Gond	566	53.35	2452	53.26
Kolam	315	29.69	1369	29.74
Pardhan	167	15.74	724	15.73
Pardhi	9	0.85	41	0.89
Mana	3	0.28	12	0.26
Mahadev Koli	1	0.09	6	0.13
Total	**1061**	**100**	**4604**	**100.01**

Present study reveals a highly concentrated distribution of tribal populations, with three communities - Gond, Kolam, and Pardhan, who collectively accounting for 98.76 % of the households and 98.73 % of the tribal population. This indicates limited ethnic diversity within the Scheduled Tribe category in this region, with the remaining communities such as Pardhi and Mana constituting less than one percentage each. In addition to these tribal groups, the villages are also home to members of other communities, though in smaller numbers. These include Kunbis, Gavaris, Kumbhars (potters), Mali, Dhangar as well as people from Sikh, Muslim and Buddhist communities are also inhabitants in the study area.

Brief outline of the studied communities

I. The Gond

The Gonds are one of the largest tribal communities in India, primarily found in the eastern districts of Maharashtra like Gadchiroli, Chandrapur, and Nandurbar. The Gonds of Maharashtra have more than 50 endogamous subgroups (Singh, 1994). Their mother tongue, Gondi belongs to the Dravidian family of languages. However, they can converse well in Hindi and Marathi too. Agriculture is their primary occupation. They speak Gondi, a South-Central Dravidian language, and Marathi, especially in areas with close contact to non-tribal people. According to the Census of India (2011), their population in the state is about 2.2 million. In education, the literacy rate among the Gonds is 59.9%. Male literacy is about 70 %, while female literacy is around 50 % (Census of India, 2011).

II. The Kolam

The Kolam community is recognized as a Particularly Vulnerable Tribal Group (PVTG) and primarily resides in the Yavatmal and Chandrapur districts of Maharashtra. Kolam are also known as the Kolavar and Pujari and their well- distributed in districts of Vidarbh region, Maharashtra (Singh, 1994). In Mahastra, Kolam are also notified as Mannervarlu. They are the one of the particularly vulnerable tribal groups (PVTGs) of India. The Kolam speak in Kolami, a Dravidian language among them, though they are well-versed in Marathi and Hindi. In Maharashtra, they are divided into 12 exogamous clans. As of the 2011 Census, their population was about 24,000 individuals. Kolams have one of the lowest literacy rates among tribal groups in Maharashtra, at 52.2 % (male: 60.8 %, female: 44.1 %) (Census of India, 2011).

III. The Pardhan

The Pardhan is one of the endogamous tribal communities of Maharashtra. In this state they are also known by different names like Parganiha Desai and Pathari. There are three major groups of the tribe - Raj Pardhan, Gond Pardhan and Theti Pardhan in the study area. Agriculture is their primary subsistence. In addition, they also earn livelihood by selling forest produces. They speak in Gondi dialect in addition to Marathi and Hindi (Singh, 1994). They mainly live in Gondia, Gadchiroli and Nandurbar districts, having population between 80,000 and 100,000 (Census of India, 2011). The community has a moderate literacy rate of 55–60 %, though female literacy and secondary education completion remain low (Census of India, 2011).

IV. The Pardhi

The Pardhi tribe, once a nomadic and hunting community, has faced major socio-economic changes, especially after being stigmatized under the Criminal Tribes Act of 1871. Traditionally, Pardhis worked for local kings and landlords as hunters and trackers due to their deep understanding of forests and animals. Unfortunately, after their lifestyle was criminalized during British rule and hunting was banned post-independence, Pardhis became marginalized, surviving on petty trade, daily wage labor, circus performances, and informal vending (Bhukya, 2008). Their current population is about 450,000, scattered across Nagpur, Amravati, Jalgaon, and parts of Marathwada (Census of India, 2011). Their literacy rate is among the lowest of tribal communities, between 45–50 %. Many children drop out of school due to stigma, nomadic lifestyles, and poverty (Ministry of Social Justice & Empowerment, 2018).

V. The Mana

The Mana is also known as Mane or Mani (Singh, 2004). They are distributed in the district of Chandrapur, Gadchiroli, Yavatmal, Bhandara, Amravati, and Nagpur of Maharashtra. They are also an endogamous tribal group and speak in Marathi, Hindi and Gondi. Historically, the Manas engaged in wet and dry agriculture, growing *jowar (Sorghum bicolour*), *paddy (*Oryza sativa), *and pulses (Fabaceae or Leguminosae)*. They also collect forest products and migrate seasonally for farm work. Compared to other tribes, the Mana has a longer history of integrating into settled village economies and owning land (Sharma, 2004). Their population is estimated to be between 110,000 and 130,000 individuals (Census of India, 2011). Literacy rate among Manas is relatively high, around 63 %, with better female literacy compared to more isolated tribes (Census of India, 2011; NFHS-5, 2021).

VI. The Mahadeo Koli

Mahadeo Kolis are also refer as the Dongar Koli and sometimes as the Raj Koli (Singh, 2004). They are Marathi speaker, though they can converse in Hindi. They practice clan exogamy but they are endogamous tribe. Cultivation and agriculture wage labour is the primary means of livelihood.

Villages - Contextual to Agriculture and Health Services

Across the heartland of Maharashtra, a vibrant yet challenging picture of village life emerges, one shaped not just by soil and seasons, but also by the pulse of human effort, ecological uncertainty, and the reach (or absence) of institutional support. The stories of these 25 villages offer a window into how communities negotiate their livelihoods amidst changing water availability, pest infestations, labor dynamics, and access to both agricultural and health services.

Table 1.3. Village Features related to Agriculture and Health Services

Sl. No.	Village	Primary source of irrigation	Availability of Water for cultivation	Distance from Agricultural Extension Office (in Km.)	Distance from nearest Health Centre (PHC) (in Km.)	Agro-Ecological and Labour Features
1	**Arni**	Mixed	Moderate	2.8	2.9	Mixed irrigation; moderate soil fertility; semi-arid; moderate labor availability; seasonal pest infestation
2	**Babhulgaon**	Canal	Adequate	6.4	3.9	Canal-based; fertile alluvial soil; plain terrain; good labor; pest issues with cotton and soybean
3	**Darwha**	Mixed	Adequate	6.3	1.4	Mixed irrigation; loamy soil; hilly tracts; moderate mechanization; pest-prone
4	**Digras**	Borewells	Adequate	3.5	3.8	Borewell dependent; black cotton soil; pest pressure during kharif
5	**Ghatanji**	Reservoir	Low	7.1	5.7	Reservoir-based; undulating terrain; shallow soil; water scarcity hampers irrigation
6	**Kalamb**	Borewells	Moderate	9.9	2.9	Borewells; rocky terrain; red soil; limited pest issues; moderate labor
7	**Kelapur**	Canal	Low	4.1	6.1	Canal-fed; low fertility; drought-prone; low mechanization; fall armyworm incidents
8	**Mahagaon**	Reservoir	Moderate	8.8	1.7	Reservoirs; medium black soil; semi-arid ecology; shortage of labor; pest presence during monsoon
9	**Maregaon**	Open Wells	Low	9.1	2.9	Open wells; shallow soil depth; hill base village; labor deficit
10	**Ner**	Reservoir	Adequate	7.8	5.9	Reservoir-fed; fertile soils; moderate pest risks; hilly plain transition
11	**Pandharkawda**	Borewells	High	2	7.1	Borewells; loamy soil; high cropping intensity; fall armyworm & bollworm prevalent
12	**Pusad**	Canal	Moderate	8.4	5.8	Canal; medium black soil; rain-fed fallback; seasonal migrant labor; pest-sensitive
13	**Ralegaon**	Open Wells	Low	7.1	7.3	Open wells; undulating uplands; dry spells; weevils & soil pests common
14	**Umarkhed**	Reservoir	Adequate	3.6	3.1	Reservoir-based; silty-clay soil; moderate mechanization; low pest incidence

15	**Wani**	Canal	Adequate	8.3	2.6	Canal irrigation; rich soil; pest challenges during post-monsoon
16	**Zari Jamani**	Borewells	Adequate	8.5	1.8	Borewell; hard terrain; cotton-dominated; bollworm outbreaks
17	**Tipeshwar**	Mixed	Moderate	9.8	6.3	Mixed irrigation; semi-fertile soil; termite-prone; water stress visible
18	**Rajur**	Canal	High	2.3	6.6	Canal-fed; saline patches; high productivity; leaf curl virus seen
19	**Bhivapur**	Mixed	Adequate	5.8	1.6	Mixed irrigation; uneven terrain; intermittent labor; white grub infestation
20	**Chimur**	Reservoir	Adequate	4	5.9	Reservoir-fed; medium fertility; cotton-sorghum zone; vector-borne crop issues
21	**Hinganghat**	Reservoir	Adequate	5.7	7.8	Reservoir-based; red soil; poor retention; health risk with stagnant water
22	**Deoli**	Canal	Low	2.8	3.9	Canal; degraded soil patches; medium pest load; migration for work
23	**Karanja**	Open Wells	High	9.8	5.5	Open wells; favorable cropping belt; labor-intensive; root borer problems
24	**Selu**	Borewells	Low	5.5	7.3	Borewells; dry belt; erratic rains; herbicide-resistant weed issues
25	**Manora**	Open Wells	High	9.6	3.5	Open wells; sugarcane & paddy mix; waterlogging; bacterial wilt observed

Water: Lifeline of the Land

In villages like Rajur, Pandharkawda, and Karanja, where irrigation systems are well-established, be it canals or open wells, farmers enjoy the rare privilege of high water availability. These are the places where agriculture flows more rhythmically, where cropping calendars are predictable, and where yields can be bountiful.

But not far away scenario changes in other places. Kelapur, Ghatanji, and Selu know what it means to wait for rain, to ration water, and to watch crops wither. Their soils may be decent, but the skies and water sources often betray them. Borewells, reservoirs, and open wells are the primary sources here, but they’re fickle. Reservoir-fed regions like Ghatanji and Chimur often struggle when rainfall is scant, and the water table dips year after year.

Villages with mixed irrigation systems like Arni, Darwha, and Tipeshwar, sit somewhere in between. They depend on a bit of everything—wells, canals, rain—and this hybrid strategy lends some flexibility, though not always reliability.

Soil, Terrai and the Language of the Earth

Each village tells a different tale through its soil. The black cotton soils of Digras and Mahagaon are cherished by farmers for their moisture-retaining qualities. But these very soils also attract pests during the kharif season, an irony not lost on those who tend the land.

Some places, like Babhulgaon, sit atop alluvial riches, their plains fertile and easy to cultivate. Others, like Kalamb and Ralegaon, contend with rocky terrain and uplands that make ploughing laborious and mechanization difficult. Rajur faces salinity patches that threaten productivity despite high irrigation, while Manora, ironically rich in water, often battles bacterial wilt due to waterlogging.

In every corner, nature speaks a different dialect,be it the semi-arid soils of Tipeshwar, the loamy textures of Pandharkawda, or the silty-clay layers of Umarkhed. And the farmers! They've learned to read the soil like scripture, adapting their crops and techniques accordingly.

Pests, Weeds and Invisible Enemies

Pest infestations have become an inseparable part of the agricultural life. The bollworms and fall armyworms that plague Pandharkawda, Kelapur and Zari Jamani have turned cotton cultivation into a high-risk venture. Leaf curl viruses in Rajur and white grubs in Bhivapur strike without warning. And in Selu, even the weeds have evolved - resisting herbicides and demanding more labor than ever.

The story here is one of constant vigilance. Farming is no longer just about sowing and harvesting; it is an unending war against invisible foes.

The Hand that Tills: Labor and Mechanization

While Babhulgaon and Pandharkawda report good labor availability, others like Mahagaon and Maregaon are witnessing a steady drain of manpower. Migration, aging populations and a shift away from agriculture are hollowing out the rural workforce. Intermittent labor in places like Bhivapur makes timely sowing and harvesting difficult, especially for crops that can't wait.

In some villages, the machines have started to step in Darwha and Umarkhed, for instance, show moderate mechanization but in many others, terrain, cost, and access still keep tractors and harvesters out of reach.

Distance Matters- Role of Institutions

How close a village is to an Agricultural Extension Office, or a Primary Health Centre can make a world of difference. Pandharkawda and Rajur, being just a couple of kilometers away from their respective offices, benefit from quick advice, faster delivery of seeds and inputs, and timely healthcare.

But then there's Hinganghat, Selu, and Ralegaon, where even a basic health checkup can mean a journey of over 7 km—often on unreliable roads. For the elderly, pregnant women, or those battling pesticide exposure or water-borne illnesses, this distance is not just inconvenient—it can be life-threatening.

A Tapestry of Struggles and Strengths

Despite the odds, these villages endure. They experiment with crop varieties, organize against pests, share labor, and lean on traditional wisdom when modern institutions fall short. The cotton-sorghum zones of Chimur, the sugarcane and paddy mixes in Manora, and the high cropping intensity in Pandharkawda showcase the agricultural creativity and resilience of rural communities.

At the same time, vulnerabilities are everywhere—whether it's the termites in Tipeshwar, vector-borne crop diseases in Chimur or the migration-for-work dilemma in Deoli. These are not just agricultural issues but social and ecological ones that intersect with gender, caste, infrastructure, and climate change.

Final Reflections

This detailed village-level picture helps us move beyond aggregate statistics and into the living realities of rural Maharashtra. Each village, with its unique combination of land, labor, water, and risk, demands location-specific policies, grounded in participatory planning and eco-sensitive development.

It is not enough to deliver seeds and fertilizers. What’s needed is an integrated approach one that addresses water security, pest management, soil restoration, health access, and labor dignity, so that agriculture remains not just a livelihood, but a sustainable way of life.

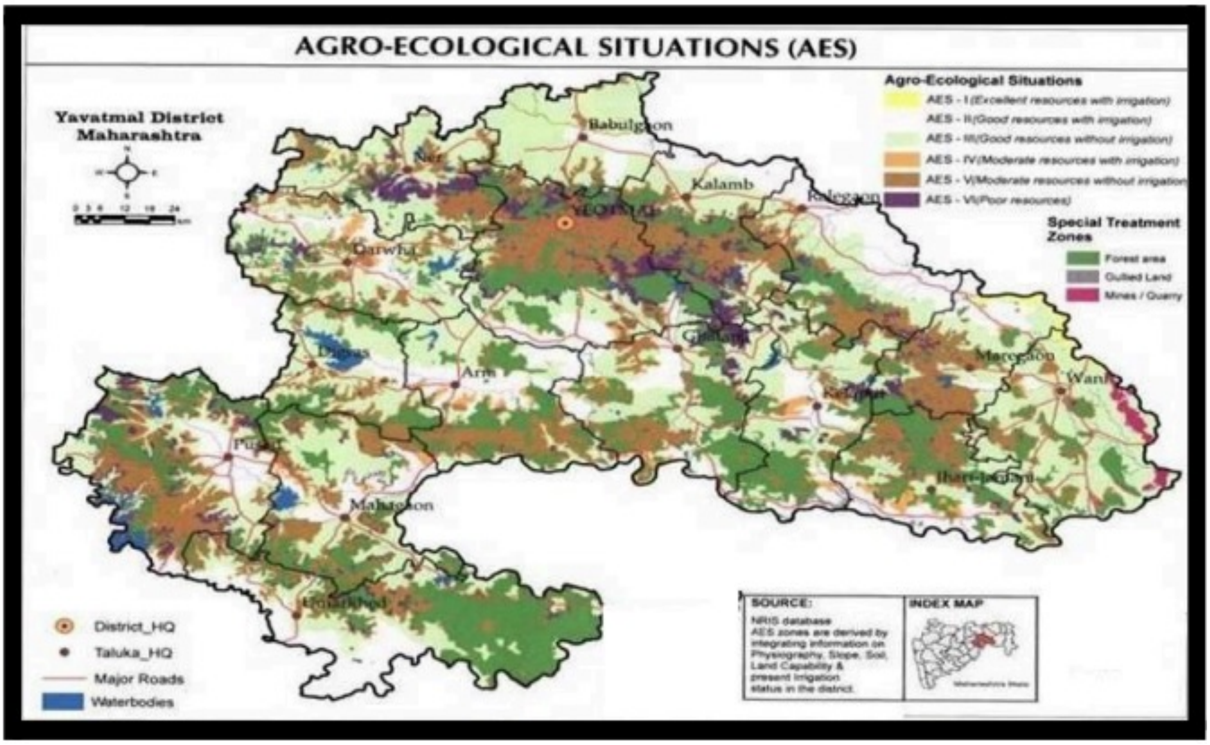
CHAPTER 2

AGRICULTURAL SCENARIO

Yavatmal district is not just as a geographical entity, but as a living, breathing agricultural ecosystem. Known as one of the prominent agrarian regions in Maharashtra, Yavatmal's diverse agro-ecological character plays a vital role in shaping the lives of its farmers, the crops they grow, and the challenges they face. Agro-ecological zone of the Yavatmal district is divided into five distinct Agro-Ecological Situations (AES) (SREP) These zones, each marked in a different color in the map, reflect the natural wealth of the land — its soils, water resources, rainfall patterns, and access to irrigation (Map 2.2.). These are not just technical classifications; they represent the agricultural destiny of thousands of families, who depend on the land for their livelihood management.

Present chapter delineats agricultural scenario under prevailing ago-climatic conditions of the Yavatmal district.

MAP 2.2: Agro-Ecological Situations (AES)



*(**Source:*** Strategic Research & Extension Plan (SREP), Government of Maharashtra (Department of Agriculture) World Bank Assisted Nanaji Deshmukh Krushi Sanjivani Project (NDKSP) (Project on Climate Resilient Agriculture) District Project Implementation Unit, Yavatmal.)

Agro-ecological Situation of Yavatmal district

AES-1: The Lush Green Promise (High Resource with Irrigation)

In parts of the central and western talukas, such as Kalamb, Babulgaon, and Ner — the land breathes with abundance. These areas fall under AES-1, marked in dark green, where the combination of fertile soils, favorable climate, and access to irrigation allows for multiple crops. Here, farmers are more secure, with better yields of cotton, soybean, and pulses. These areas serve as the agricultural backbone of the district.

AES-2: Green but Thirsty (High Resource without Irrigation)

Moving slightly outward, we find lands marked in light green AES-2. These areas share the same soil richness but lack consistent irrigation. Farming here is purely rain-fed. A good monsoon brings prosperity; a weak one brings worry. Farmers in this area are resilient, adapting with techniques like rain-fed cultivation and mixed cropping.

AES-3 and AES-4: The Struggle of the Middle Ground

In the orange and brown zones — AES-3 and AES-4 — farmers work against the odds. These are moderately endowed regions, with either limited irrigation or none at all. Spread across Arni, Ghatanji, and Umarkhed, the land is semi-fertile, and farming here often reflects a careful balancing act between tradition and survival. These are the areas where government interventions — through watershed development, drip irrigation, and soil health programs — can make a real difference.

AES-5: Where the Earth Demands More (Low Resource Zone)

The purple patches on the map represent AES-5 — low-resource areas scattered in the southern and eastern fringes, including parts of Pandharkawda, Wani, and Kelapur. These are the toughest terrains for agriculture. Thin soils, poor water retention, and harsh climate make cultivation a real struggle. Farmers in these zones are often the most vulnerable, relying on drought-tolerant crops or seasonal migration to survive. Present study area Kelapur tehsil falls under this agro-ecological system – AES-5.

Special Zones: Where Nature Takes Over

Besides agriculture, Yavatmal is also home to forests, mines, and cultivable wastelands. These special treatment zones are shown through unique patterns on the map — forests marked in green hatch, mines in pink dots, and wastelands in grey. These areas are ecologically sensitive and economically important. Forest zones support biodiversity and tribal livelihoods, while mines present both opportunities and environmental concerns.

Crop pattern and Production

Agricultural practices in the Kelapur tehsil mainly relies on rainwater and aligns with the south-west monsoon. As shown in the table, households often grow multiple crops during the *kharif* and *rabi* seasons, leading to overlapping growing cycles. Therefore, the percentages in the table indicate multiple responses and add up to more than 100 percent. This practice of growing more than one crop helps tribal farmers cope with unpredictable weather, market changes, and their food needs.

Now it is essentially required to reveal the current crop pattern and crop calendar among tribal farmers of Kelapur Tehsil, Yavatmal district, which shows households agricultural activities that had been carried out for growing different types of crops in a year (Table 2.1).

TABLE 2.1. CURRENT CROP PATTERN AND CROP CALENDER

Crop	HH (No.)	HH (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Paddy	650	61.26	Fallow			Preparation of nursery bed	Ploughing of land	Sowing	Transplantation	Growing		**	Harvest	
Cotton	720	67.86	Harvesting		Fallow		Field preparation	Sowing	Growing			Harvest		
Soybean	480	45.24	Fallow				Field preparation	Sowing	Growing		Harvest		Fallow	
Tur (Pigeon pea)	350	32.99	Fallow				Land preparation	Sowing	Growing			**	Harvest	
Wheat	280	26.39	Sowing	Growing	Harvest		Fallow							
Potato	150	14.14	Growing	Harvest		Fallow						Transplantation	Growing	Growing

*(**Source:** 1061 first hand households field data, surveyed during December 2024–January 2025)*

PC 133, Bolgard, Rashi, 767, 779, Brahma, Jumbo, Rashi, Moksha, Dhandev, Super, Sriram, Kabaddi, Jangi, Tulsi, 356, 779, 797, 659, Panch, Tiger are the most grown cotton varieties in the studied villages. It is the most widely grown crop in the area, with 720 households (67.86 %) reporting its cultivation. Preparing the fields for cotton is intensive in the pre-monsoon months, with sowing taking place in June and harvesting from October to December. Prominence of cotton shows that farming in Kelapur Tehsil is becoming more commercial, relying more on agro-chemicals and machinery.

Paddy is grown by 650 households (61.26 %), especially in villages with access to irrigation canals, reservoirs, or low-lying fields. Paddy growing schedule includes nursery preparation in April, land preparation in May, sowing in June, transplantation in July, and harvesting in November and December. Rice is vital for food security for tribal farmers.

Soybean is cultivated by 480 households (45.24 %) during the kharif season. It is sown when the monsoon starts in June, with harvesting occurring between September and October. Soybean acts as both a cash crop and a crop that improves soil health (maintain nitrozen cycle in crop fields). KDS-344 JS-335 MAUS-71, MACS-450 and DS-228 are the most grown soybean varieties in this area.

Tur (pigeon pea) is grown by 350 households (32.99 %) and is valued for its drought resistance and nutritional benefits. Maroti, Munni, Ganesh, Early, Daftari and Durga are the popular varieties *tur*, which are usually sown in May and June and harvested in November and December, often intercropped with cotton or soybean.

Wheat, although a Rabi crop, is grown by a smaller proportion of households (280 households, 26.39%). Sowing occurs in January, and the crop is harvested in April and May. Limited irrigation facilities constrain its wider adoption.

Potato, cultivated by 150 (14.04 %) households, appears as a minor crop grown primarily for household consumption or sale in local markest. Transplantation is done in October and harvesting occurs during February and March.

Existing crop calendar clearly illustrates the month-wise engagement of tribal farmers across for various crops, aligning with the agro-climatic conditions, which will discuss in detail in the Chapter-4.

Current agricultural production scenario in Kelapur tehsil reveals a diverse cropping pattern encompassing both food and cash crops (Table 2.2.). Based on agricultural statistics for the 2023–2024 *kharif* and *rabi* season of the Kelapur tehsil, a comprehensive assessment of crop-wise area, yield, and market value has been carried out for the Kelapur block.

Food Crops

Total area under food crop production stands at 611,871 hectares, reflecting the significance of multi-cropping and food security sustains in the region. Kelapur's agrarian economy is heavily dependent on food crop cultivation, with an extensive area devoted to pulses, cereals, and oilseeds. Among food crops soyabean stands out as the principal crop, covering approximately 292,476 hectares. It yields about 801.12 kg/ha, which translates to nearly 3.24 quintals per acre. This crop is pivotal for both local consumption and market sale, fetching an approximate market price of ₹45 per kilogram. Tur (Red Gram), another staple legume, is cultivated over 111,824 hectares, yielding 518 kg/ha or 2.10 quintals per acre. It is a critical source of protein and commands a strong market value of ₹85/kg due to its dietary demand. Gram (Chana) is an important Rabi crop, grown on 147,655 hectares with an average yield of 743 kg/ha (3.00 quintals/acre). It is not only vital to food security but also a significant contributor to soil health due to its nitrogen-fixing capacity. Wheat is grown on 49,102 hectares in the Rabi season, with a yield of 1055 kg/ha (approx. 4.27 quintals/acre). It remains an essential food grain for the population and is traded at around ₹22/kg in local markets. Groundnut, cultivated in smaller patches covering 7,732 hectares, achieves an average yield of 585 kg/ha (2.36 quintals/acre). This oilseed crop has both nutritional and commercial value, fetching ₹55/kg in markets. Jowar, although on a declining trend, is still cultivated over 3,082 hectares with a yield of 252 kg/ha (1.02 quintals/acre), supporting dietary diversity for local communities.

TABLE 2.2. CURRENT CROP PRODUCTION STATUS OF KELAPUR (2023-2024)

Type	Major Crop	Area Under Production (Ha.)	Yield (Kg/Ha.)	Yield (Quintal/Acre)	Market Rate (₹/Kg.)
FOOD CROP	Soyabean	292476	801.12	19.79	45
	Tur (Red Gram)	111824	518	12.79	85
	Gram (Chana)	147655	743	18.35	70
	Wheat	49102	1055	26.06	22
	Groundnut	7732	585	14.45	55
	Jawar	3082	252	6.22	20
Total		**611871**			
CASH CROP	Cotton	462707	218	5.38	62
Total		**462707**			

(***Source:*** Agricultural Technology Management Agency (ATMA), Department of Agriculture, Government of Maharashtra, District Agriculture Office, Yavatmal Discrict, *Strategic Research and Extension Plan (SREP), 2023-2024 Yavatmal District*. Government of Maharashtra)

Cash Crop

Among cash crops, cotton dominates the agrarian landscape of Kelapur. Grown over a substantial 462,707 hectares, it yields an average of 218 kg/ha, equating to around 0.88 quintals per acre. Despite its relatively lower productivity compared to other regions, cotton continues to be a prime economic crop due to its demand in the textile industry. Its market price, averaging around ₹62 per kilogram, offers crucial income support to farmers even under erratic monsoon conditions and soil fertility challenges.

Crop production status of Kelapur tehsil for the current year (2023-2024) indicates a predominantly food crop-oriented landscape, with soybean and pulses occupying a significant portion of cultivated land. While the cropping intensity reflects efficient land use and adaptive farming strategies, market rate disparities and fluctuating yields indicate the need for intervention in the form of irrigation support, improved seeds, and marketing linkages. Cotton, the sole major cash crop, remains vital for the rural economy despite its input-intensive nature and climate vulnerability. This assessment provides a clear snapshot of Kelapur's agricultural productivity, enabling targeted planning for resource allocation, crop diversification, and agro-economic resilience.

Social groups and their engagement in agriculture

TABLE 2.3. Social group wise distribution of Agricultural Land Holding in Kelapur (2023-2024)

Social Categories	Barren & Uncultivable land (%)	Cultivable waste (%)	Fallow land other than Current Fallow (%)	Current Fallow (%)	Net Sown Area (%)	Total Agricultural land
Scheduled Caste	3.2	1	2	5.5	88.3	100
Scheduled Tribe	4.5	1.5	2.8	6.2	85	100
Other Backward Classes	2.8	0.9	1.5	4.1	90.7	100
Others	3	1.2	1.9	4.9	89	100
Total	**3.38**	**1.15**	**2.05**	**5.18**	**88.25**	**100.01**

(***Source***: Strategic Research and Extension Plan (SREP), Yavatmal District, Department of Agriculture, Government of Maharashtra, District Project Implementation Unit (DPIU), Nanaji Deshmukh Krushi Sanjivani Project (Climate Resilient Agriculture Project), 2023–2024)

Primary economic pursuits among tribal households in Kelapur taluk is agriculture. Even individuals, who are landless also earn livelihood through wage labour from crop fields. In This section discusses involvement of various social groups in crop productions in terms of possession of agricultural land and thereafter engagement of landless households in agricultural sector as wage labourer.

Scheduled Castes (SC)

SC households hold approximately 3.2 % of their land as barren and uncultivable, which is slightly below the average. Cultivable waste accounts for 1.0 %, while fallow land other than current fallow makes up 2.0 %. Percentage of current fallow land is 5.5 %, indicating that a small portion of cultivable land remains unused seasonally. Significantly net sown area constitutes 88.3 %, suggesting high utilization of available land among SCs, likely due to land fragmentation and dependence on seasonal crops.

Scheduled Tribes (ST)

ST scenario exhibit the highest percentage of barren and uncultivable land (4.5 %) and fallow other than current fallow (2.8 %), indicating resource constraints possibly related to terrain and rain-fed practices. Cultivable waste stands at 1.5 % and current fallow land at 6.2 % —the highest among all groups. Despite these constraints, net sown area is at 85.0 %, which still reflects a relatively efficient usage of land, albeit slightly lower than other groups.

Other Backward Classes (OBC)

The OBC category reflects the lowest percentage of uncultivable (2.8 %) and cultivable waste land (0.9 %) among all categories. Current fallow land at 4.1 % is the lowest, indicating effective land use practices and better access to agricultural inputs. Their net sown area is the highest at 90.7 %, suggesting relative land security and better adaptation to cropping patterns.

Others (General Category)

This group shows 3.0 % barren land, 1.2 % cultivable waste, and 1.9 % fallow other than current fallow land. Current fallow is recorded at 4.9 %, and net sown area at 89.0 %, which is comparable to the OBC category, hinting at better land use efficiency than the STs.

Average figure across all social groups indicates that net sown area constitutes approximately 88.25 %, reflecting intensive use of agricultural land in Kelapur. The current fallow land averages 5.18 %, and cultivable waste averages 1.15 %. These values point to seasonal fallow practices and areas with scope for better land management interventions.

Social groups and crop production

Total net sown area for Kelapur tehsil is estimated at 90,950 hectares, based on secondary sources including the Strategic Research and Extension Plan (SREP, 2024) of Yavatmal District and land-use statistics from government records. Given the absence of direct caste-wise, crop-specific data at the tehsil level, this study uses a proportional estimation method. Major crops identified from Kelapur and Yavatmal region include cotton, soybean, *tur* (Pigeon Pea), wheat, and black gram (*chana*). Total net sown area was evenly distributed across these five major crop types for estimation. Social group distribution per crop was derived from district-level demographic trends and adjusted based on known patterns of landholding inequality, caste-based access to land, and traditional cropping practices.

Table 2.4. Social group wise distribution of Net Sown Area under various Crops in Kelapur (2023-2024)

Crops	Scheduled Caste (%)	SC Area	Scheduled Tribe (%)	ST Area	OBC (%)	OBC Area	Others (%)	Others Area	Total Area
Cotton	12	1819	25	3789.58	40	6063.33	23	3486.42	15158.33
Soybean	10	1515.83	20	3031.67	45	6821.25	25	3789.58	15158.33
Tur (Pigeon Pea)	15	2273.75	30	4547.50	35	5305.42	20	3031.67	15158.33
Wheat	8	1212.67	10	1515.83	50	7579.17	32	4850.67	15158.33
Gram (Chana)	10	1515.83	15	2273.75	50	7579.17	25	3789.58	15158.33
Others	10	1515.83	20	3031.67	45	6821.25	25	3789.58	15158.33

(***Source***: Sowing Report and Agricultural Labour Statistics, Department of Agriculture, Government of Maharashtra, District Agriculture Office and District Statistical Office, Yavatmal, 2023–2024)

Distribution of agricultural land use among different social categories in Kelapur tehsil provides insight into the socio-economic dynamics of rural agrarian society. Table 2.4. shows how net sown area of major crops grown in Kelapur is distributed among Scheduled Castes (SCs), Scheduled Tribes (STs), Other Backward Classes (OBCs), and Others.

Cotton and Soybean, the leading crops in Kelapur, show relatively higher land use by OBCs (40–45 %) and STs (20–25 %), indicating their dominant role in both commercial and subsistence farming. Scheduled Castes hold between 8–15 % of crop-specific net sown areas, consistent with historical land access limitations. Tur (Pigeon Pea) crop, often grown on marginal land, shows a greater share (30 %) for STs, reflecting their residence in less fertile zones.

Black gram and wheat show a more equitable spread, with OBCs controlling around 50 % of net sown area in both cases. The "Others" category, which includes general caste landowners and institutional holdings, accounts for 20–32 % across crops.

Landless farmers

Table 2.5. Social group wise distribution of Landless Farmers in Kelapur (2023-2024)

Social Categories	Total No. of Wage labourers	Labourers, who Migrated to other places (%)	Labourers, who are Migrated from other places (%)
Scheduled Caste	15,603	0.02%	0.22%
Scheduled Tribe	12,990	0.00%	1.08%
Other Backward Classes	8,025	0.00%	0.32%
Others	6,723	0.01%	0.25%
Total	**43,341**	**0.03%**	**1.87%**

(***Source***: Sowing Report and Agricultural Labour Statistics, Department of Agriculture, Government of Maharashtra, District Agriculture Office and District Statistical Office, Yavatmal, 2023–2024)

Landlessness tribal farmer remains a critical issue in the agrarian structure of Kelapur, where a substantial proportion of the population continues to depend on wage labour for sustenance. Distribution of landless agricultural labourers across different social categories reflects entrenched inequalities and ongoing socio-economic vulnerabilities among Scheduled Castes (SCs), Scheduled Tribes (STs), Other Backward Classes (OBCs), and other communities.

Table 2.5., depicts the total number of wage labourers in Kelapur stands at 43,341, distributed across four major social groups. Among those, Scheduled Castes (SCs) constitutes the highest number of landless wage labourers, accounting for 15,603 individuals, followed by Scheduled Tribes (STs) with 12,990, Other Backward Classes (OBCs) with 8,025, and 'Others' with 6,723 landless labourers.

Migration pattern among these groups reveals important socio-economic trends. The Scheduled Caste labour force shows a 0.02 % migration rate to other places, while 0.22 % of SC labourers are reported to have migrated into Kelapur for better livelihood opportunities in the agri-cultural sector. In case of Scheduled Tribes, there is no significant outward migration has been reported, but a 1.08 % inward migration indicates that agricultural sector of the

Kelapur is a viable destination for earning livelihood particularly during sowing and harvesting season for tribal people of adjacent *tehsil*s.

OBC labourers show no outward migration, but about 0.32 % has migrated into the area. Meanwhile, among the communities, other than SC, ST and OBC, 0.01 % migrated out, and 0.25 % migrated in, likely reflecting small-scale mobility driven by informal labour demands during peak agricultural seasons.

These figures underline the dependency of vulnerable social groups on migratory labour for survival, especially among Scheduled Tribes and Castes. The low rates of outward migration among STs may also reflect geographical immobility due to cultural, linguistic or economic constraints.

Migration data further suggests that Kelapur functions not only as a source efficient agricultural labourer but also as a recipient region for efficient agricultural labourers from neighbouring talukas/areas, particularly during the sowing and harvesting seasons. These patterns are reflective of a broader seasonal labour economy that characterizes rural Maharashtra.

Intensified agriculture – a Passion or Compulsion!

As it has already discussed in general that there are lot of changes have taken places in cultivation practices as well as land management during last four decadeds in villages of Kelapur taluka, as it is inevitable. Here some specific aspects are mentioned in understanding degree and dimensions of transformation in agricultural practices. Cultivation of multiple crops in the same field to maximize land use and reduce risk is now quite conventional in this area. For instance, in the studied area, *tur* is often inter-cropped with cotton or *jowar*.

During discussion with farmers, it reveald that traditional organic inputs like cow dung manure and vermin compost were enough for the production of healthy crops and abundant yield in yesteryears. Farmers managed to get good yields just by relying on these natural methods. However, the situation has changed significantly over the years. Today, without the application of chemical fertilizers, crop fields remain unproductive and inevitably farmers would experience crop failure. In fact, the use of fertilizers only makes cultivation possible and ensures an expected yield.

Simultaneously induction of mechanization has actively brought about a change in the arena of agriculture. Machines are being used at various stages of farming. Earlier most agricultural activities such as ploughing, tilling, transportation, weeding, etc., which were carried out by using draught animals, now noticeably more mechanized in order to reduce the time and labour. Some of the conventional agro-machines are rotavator, cultivator, *teen-fawdi, don-fawdi, panji, bed and 'v'-faas.* Rotavator is used for preparing soil for planting by breaking it up, mixing organic matter, and improving aeration and costs around Rs. 1200/- per acre of land. Cultivator is used for soil preparation, weed control, and soil mixing and costs around Rs. 900/- per acre of land. "V" Faas is used for uprooting the weed and cropping roots and it costs around Rs. 500/- per acre. Don Fawdi costs Rs. 1500/- per acre of land, Bed costs Rs. 1000/- per acre and Panji, Rs. 700/- per acre respectively. Although the use of machines for agricultural productions costs higher than traditional but farmers further depend on mechanization because of the conveniences. Indeed the mechanized farming also leed to changes in the social and economic fabric of tribal life.

For instances, purposes of *jowar* cultivation for other than food crop, which earlier was the primary source of fodder for cattles, in current years *jowar* production has declined because of crisis in water to *jowar* fields. Circumstances compelled many tribal farmers unable to retain their bullocks and other cattle. Previously farmers depended on cow-dung of own cattle as organic manure. Now they often forced to purchase cow-dung from external sources. A single trolley of manure costs around Rs.1500/- and on top of that, an additional Rs. 600/- is required just to hire the trolley for transportion. In addition to hiring of agro-machines, cost of cow-dung adds futher load on input costs on small-scale farmers, particularly who are already struggling with limited resources and fluctuating incomes.

Gradual scaricity in organic manure (cow-dung of own cattle) and shifting of food crop to cash crop productions, there has been an exponential increase in the use of chemical fertilizers and pesticides, in order to ensure bumper yields- more and more agro-chemicals are being used without considering the after-effects of that use. While using urea as fertilizer, one bag of urea (45 kilogram) is mixed with one bag (50 kilogram) of any of the other fertilisers. With each application, the quantity of fertiliser applied increases. Fertiliser is to be applied at least four times in the field. This application is done mostly by women. Though mixing of fertilisers is done by men. Men folks are also involved in the spraying of insecticides/pesticides and weedicides/herbicides. Cotton farmers have major concern of the pest - pink bollworm

(*Pectinophora gossypiella*) that causes major damages in cotton production. A substantial portion of a farmer's budget goes into purchasing of agro chemicals. To many farmers, these inputs account for a major chunk of production costs. Increasing prices in crop production often even do not compensate market return. This imbalance creates financial strain, especially when crop prices fall, or yields are affected by unforeseen events like droughts or pest attacks.

Rising costs have made it increasingly difficult for farmers to earn a sustainable income from agriculture. After heavy investment in essentials like seeds, fertilizers, and pesticides, they are often left with very little by the time they sell their produces. As a result, the returns barely cover the initial investment. Whatever small amount they do manage to earn is usually set aside for the next sowing season, leaving almost nothing for household expenses or savings. This cycle continues season after season, trapping farmers in a constant state of financial stress- for many, and agriculture is merely a means of survival.

CHAPTER 3

SOCIO-ECONOMIC PROFILE

Understanding the socio-economic profile of tribal farming households in Vidarbha is important to evaluate the broader health impacts of changing agricultural practices in that area. Population dynamics and other socio-economic variable like household type and size civic status in farmer household, level of literacy, land holding pattern, annual income level and asset ownership etc. plays significant role in understanding health risk and in community health issues. Recent studies have emphasized that small land holder farmers particularly in India tribal communities are more vulnerable to the dual pressures of agrarian transformation and health burdens due to poor literacy, limited landholding and declining income opportunity (Swaminathan et *al.*, 2020; Jadhav, 2019). Additionally, intensified cash crop cultivation and land leasing dynamics have altered income and dependency ratio, thus further amplifying health inequalities (Ashwani and Singh, 2023).

This chapter presents a clear picture of the population dynamics as well as socio-economic characteristics of tribal farmers of Kelapur Tehsil (Yavatmal district), based on household survey data.

Population dynamics

Population dynamics on age-sex structure in tribal households in the studied villages has been estimated a total of 1061 tribal households, belonging to different ethnic background from 25 tribal dominated villages of that tehisil. All together 4601 individuals were estimated and individual data on age, physiological state and gender wise distribution tribal household comprises a total of 4601 individual is presented in the Table.3.1.

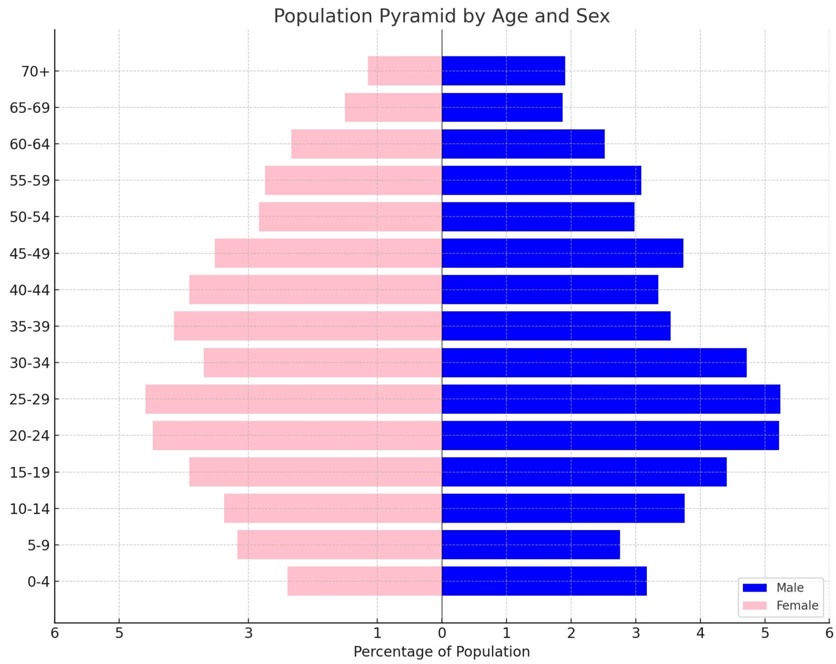
Table 3.1. Age-Sex distribution of the Household members (N: 4601)

Age groups (in years)	Sex		Total	Sex Ratio
	Male (%)	Female (%)		
0-4	146 (3.17)	110 (2.39)	256 (5.56)	
05-9	127 (2.76)	146 (3.17)	273 (5.93)	
10-14	173 (3.76)	155 (3.37)	328 (7.13)	
(0-14)	446 (9.69)	411 (8.93)	857 (18.63)	**921.52**
15-19	203 (4.41)	180 (3.91)	383 (8.32)	
20-24	240 (5.22)	206 (4.48)	446 (9.69)	
25-29	241 (5.24)	211 (4.59)	452 (9.82)	
30-34	217 (4.72)	170 (3.69)	387 (8.41)	
35-39	163 (3.54)	191 (4.15)	354 (7.69)	

40-44	154 (3.35)	180 (3.91)	334 (7.26)	
45-49	172 (3.74)	162 (3.52)	334 (7.26)	
(15-49)	1390 (30.21)	1300 (28.25)	2690 (58.47)	**935.25**
50-54	137 (2.98)	130 (2.83)	267 (5.8)	
55-59	142 (3.09)	126 (2.74)	268 (5.82)	
60-64	116 (2.52)	107 (2.33)	223 (4.85)	
(50-64)	395 (8.59)	363 (7.89)	758 (16.47)	**918.99**
65-69	86 (1.87)	69 (1.5)	155 (3.37)	
70 +	88 (1.91)	53 (1.15)	141 (3.06)	
(65 and above)	174 (3.78)	122 (2.65)	296 (6.43)	**701.15**
Total	2405 (52.27)	2196 (47.73)	4601 (100)	**913.10**

Population pyramid displays (Table 3.1 & Fig. 3.1) a tapering structure at base and gradual narrowing on the top, as ages of individuals ascending towards the elder population.

Fig. 3.1. Population Pyramid



In contrast, the older adult population (50–64 years) shows a natural declining pattern, accounting 16.47 % of the population, with a sex ratio of 918.99. Situation is more concerning in the elderly group (65 years and above), which comprises only 6.43 % of the total population. Here, the sex ratio drastically drops to 701.15, reflecting severe female under representation. Compared to the national elderly sex ratio and proportion of around 8.6 %, and Maharashtra's 6.8 %, the figures from this dataset underscore a potentially higher mortality rate among elderly women.

Demographic composition of the studied household reveals that individual under pre-reproductive age groups (0-14 years) account for 18.63 % of the total population, with a near-equal distribution between males (9.69 %) and females (8.93 %). This age bracket corresponds to the dependent population. Majority of the population (58.47 %) falls within the reproductive as well as economically productive age group (15–49 years), representing the primary labor force, who are primarily engaged in agricultural activities.

Sex ratio across different age groups reveals a consistent male predominance, with the overall sex ratio standing at 913 females per 1,000 males, notably below to the national rural average of 1,020 females per 1,000 males (NFHS-5, 2019-21).

Table 3.2. Child-Women Ratio (CWR)

Variables	Kelapur
Male Child (< 5yrs.)	135
Female Child (< 5yrs.)	102
Total Child < 5yrs.	237
Total Mothers (15-49 yrs.)	862
Male Child- Women Ratio	15.66
Female Child- Women Ratio	11.83
Overall Child-Woman Ratio	27.49

The demographic profile of Kelapur provides meaningful insights into fertility patterns and gender distribution through the lens of child-woman ratio (CWR). According to the data, there are 135 male children and 102 female children below the age of five, making a total of 237 children less than five years of ages. When compared against the 862 women in the reproductive age group (15–49 years), the overall child-woman ratio stands at 27.49, meaning there are approximately 27 children under age five for every 100 women of childbearing age. This indicator is useful for assessing recent fertility levels in the absence of complete birth history data.

Overall, the data from Kelapur tehsil reflects both declining fertility and gender asymmetry, highlighting the need for gender-sensitive public health interventions and awareness programmes aimed at promoting equity in child survival and maternal health outcomes.

Table 3.3: Distribution of household by genealogical composition (N: 1061)

Family Type	Number	%

Nuclear	619	58.34
Joint	392	36.95
Joint Extended	35	3.30
Broken/Incomplete	15	1.41
Total	1061	100.00

Household structure, based on relationship between members and head of the household, household size based on the number of members and average members in the households are being considered in understanding of household's engagement in agricultural activities. It is observed that almost 95 % household are either nuclear or joint by nature, which is the most common form of household structure among farmers. Though nuclear type of household (58.34 %) is most prevailing household form (Table 3.3) and 65.13 % of surveyed households consisted of 4 to 6 members, which comes under medium size household, whereas 1 to 3 members small household (27.52 %) had also prominent existences (Table 3.4) in the studied area. Despite household structure and size of household, this study asserts 4.34 average members at household (Table 3.5).

Table 3.4: Distribution of households by numerical size (N: 1061)

	Small	**Medium**	**Large**	**Very Large**	**Total**
	(1-3 members)	**(4-6 members)**	**(7-9 members)**	**(10 and more members)**	
No.	292	691	68	10	1061
%	27.52	65.13	6.41	0.94	100.00

Data on household size indicates a dominant trend toward medium and small family sizes, with very few households maintaining large or extended configurations. This transition is consistent with national patterns as seen in recent NFHS-5 (2019–21) data.

Table 3.5. Average member at household (N: 4601)

	Average Male members	**Average Female members**	**Average Family members**
No.	2.27	2.07	4.34
%	52.30	47.70	100.00

Civic status

Table 3.6. Marital status of members at household (N: 3390)

Marital Status	Male (%)	Female (%)	Total (%)
Unmarried	372 (10.97)	216 (6.37)	588 (17.35)
Married	1232 (36.34)	1239 (36.55)	2471 (72.89)
Widow/Widower	86 (2.54)	200 (5.9)	286 (8.44)
Separated/ Divorced	16 (0.47)	29 (0.86)	45 (1.33)
Total	**1706 (50.32)**	**1684 (49.68)**	**3390 (100)**

In this section it is to mention that individuals, who were married before the legal minimum age 21 years for males and 18 years for females, as per the Prohibition of Child Marriage Act, 2006 are not ??included in the data. Out of 3390 individuals of either gender 72.89 % are found married, where male and female represents equal proportions (Table 3.6.).

Study data reveals that bachelors are more than spinster, thus advocates livelyhood security/stability among male members in farmer society is the primary yardstick in entering into marital life. Widow/widower category comprises 8.44 % of the total, with a striking gender imbalance 5.9 % of females are widowed compared to only 2.54 % of males.

Divorced /separated individual is reported negligible proportion among them. Low prevalence likely reflects strong societal norms discouraging divorce, particularly in rural and tribal settings, where marital dissolution may carry stigma or lacks in institutional support.

Level of literacy

According to Right to Education Act 2009, citizen below to ages 6 years does are not treated as ages for enrolment in formal education. Hence this study excludes altogether 407 individuals of either gender, who are below 6 years age and rest of the individuals were considered to assess the level of literacy and educational assessment.

Table 3.7. Level of literacy and Educational status in Farmers' households (N: 4294)

Educational status	Overall scenario		
	Male (%)	Female (%)	Total (%)
Pre-literate	344 (8.01)	571 (13.3)	915 (21.31)
Primary (I – V)	411 (9.57)	328 (7.64)	739 (17.21)

Middle (VI – VIII)	489 (11.39)	401 (9.34)	890 (20.73)
Secondary (IX – X)	474 (11.04)	395 (9.2)	869 (20.24)
Senior secondary (XI – XII)	395 (9.2)	289 (6.73)	684 (15.93)
Graduation	86 (2)	46 (1.07)	132 (3.07)
Post Graduation	21 (0.49)	12 (0.28)	33 (0.77)
Vocational training	0 (0)	0 (0)	0 (0)
Technical education	13 (0.3)	4 (0.09)	17 (0.4)
Medical and paramedical education	2 (0.05)	13 (0.3)	15 (0.35)
Total	**2235 (52.05)**	**2059 (47.95)**	**4294 (100)**

Table. 3.7 reveals almost one fifth (21.31 %) of individual comes under pre-literate group. Almost 38 % of them attend formal education in primary and middle standard respectively. About the same proportion of individuals have attended formal education of secondary and senior secondary level respectively. It is noticeably observed that participation in formal education above senior secondary level was almost negligible (4.5 %), of which only 3.07 % individual had only pursued graduation. However, there are some impressive participation of attending professional courses through technical education (0.4 %) and medical education (0.3 %). Female participation (0.35 %) in medical and paramedical education is found more than male member (0.05 %) of the society.

Overall literacy rate among the surveyed households finds 78.69 %, which is lower than national literacy rate stands (80.90 %) and state literacy rate of Maharashtra (85.90 %) (PLFS, 2024).

Agricultural landholding

Table 3.8. Agricultural Landholding status of households

(Ethnic group wise, in hectare, N:1061)

Ethnic groups	Landless Household	Marginal (<1 ha)	Small (1-2ha)	Semi-Medium (2-4ha)	Medium (4-10 ha)	Large (>10 ha)	Total
Gond	187 (17.62)	30 (2.83)	155 (14.61)	121 (11.4)	46 (4.34)	3 (0.28)	542 (51.08)
Kolam	125 (11.78)	25 (2.36)	87 (8.2)	81 (7.63)	23 (2.17)	0 (0)	341 (32.14)
Pardhan	84 (7.92)	13 (1.23)	39 (3.68)	19 (1.79)	6 (0.57)	1 (0.09)	162 (15.27)

Others*	0 (0)	2 (0.19)	7 (0.66)	5 (0.47)	2 (0.19)	0 (0)	16 (1.51)
Total	396 (37.32)	70 (6.6)	288 (27.14)	226 (21.3)	77 (7.26)	4 (0.38)	1061 (100)

(***Note:*** *(i) Households of Mahadev Koli, Mana and Pardhi were found in very small number. Hence, those households are clubbed together and referred as "Others", (ii) Landholding classification follows Classification of Agricultural Census 2015-2016, PIB, GoI.*)

On enquiring upon possession of cultivable land among 1061 surveyed tribal households, a significant portion of them (37.32 %) were reported landless (Table. 3.8). Since Gond, Kolam and Pardhan are the major ethnic groups, they are the primary stake holders of cultivable lands in this area but mostly are 'small' (27.14 %) to 'semi-medium' (21.30 %). In the existing cultivation system landless Gond, Kolam and Pradhan also significantly contributes in local economy as agricultural wage labour almost for period of 6 months to 8 months in a year, engaging themselves in cotton and soybean production and rest of the period they engage themselves as daily wage labour in non-agricultural sectors in and around their villages.

Table 3.9. Status of Leased out Agricultural land for cultivation (N: 81)

Leased out land (in Acre/ha.)	Number of Households	%
1-5 (<2.02 ha.)	54	66.67
6-10 (2.4-4.04 ha.)	21	25.93
11-15 (4.45-6.07 ha.)	3	3.70
15-20 (6.07-8.09 ha.)	3	3.70
21-25 (8.5-10.11 ha.)	0	0.00
>25 (10.11 ha.)	0	0.00
Total	**81**	**100.00**

During this study leasing out land was another parameter to get an idea of intensity of crop productions, particularly the cash crops in this area, where human resources along with modernization is essentially required for manoeuvring the productions with expectations of profitable return from land resource. It was reported that out of 1061 tribal farmer households merely 81 households (7.63 %) usually leased out land for crop production. And mostly the 'marginal', 'small' and 'semi-medium' landholding households tend to lease out agricultural land for crop production to sharecroppers for instant hard cash in each season and that figured out about 92.60 % of farmer households together of those categories (Table. 3.9).

Cultivation system

Traditional systems of land ownership and tenancy still influences land use pattern. Sharecropping and informal leasing arrangements (especially *bataai*) persist, particularly among landless or marginal farmers. A small portion of the 'small' farmers are engaged in cultivating their own land. Leasing out of land is found to be more lucrative among semi medium and medium farm land holders in terms of immediate hard cast without facing risks because of erratic climatic beheaviour. Cash rent (also referred as *thekka*) is a very prevailing practice of the agrarian system of Kelapur. Here, the cultivator has to pay a fixed rent in cash to the landowner regardless to crop variety or the yield. The landowner's land is leased to the cultivator in return of money. In this system the landowner provides the land, and sometimes basic inputs like seeds or fertilizers, while the cultivator contributes labour and sometimes part of the inputs. After harvesting of crop, the total yield is divided between the landowner and the cultivator, usually in a fixed proportion (e.g., 50:50 or 60:40). While the land belongs to one family member, the land is commonly cultivated by relatives. This reflects a mutual understanding among keen groups rather than entering any formal contract.

Other than leasing out of land to some close kins, in most of the cases, share croppers belongs outside kin groups and client-patron relationship strongly exists. In this relationship, landowners, moneylenders, and traders serve as patrons, while small farmers and landless labourers function as their clients. In the studied villages of Pandharkawada, remnants of the Ijardari system - also known as revenue farming - is still be observed. A large expanse of land was once controlled by the *ijardar*, under whom villagers worked as labourers on his land, receiving a monthly wage. However, following the implementation of land ceiling act and the Maharashtra *Kul Kayda* Act (referred to as the Maharashtra Tenancy and Agricultural Lands Act, 1948), much of this land was redistributed to the farmers - often granting ownership to those who had long cultivated it. The primary objective of the *Kul Kayda* Act was to improve the economic and social conditions of the rural population by ensuring fair land distribution and protecting the rights of those who work the land. Some of the *ijardars* of the villages studied were- Mangurda - Mangurdekar, Wai - Mankar, Dhoki (Wai) - Kale, Munjhala - Nandurkar, Niljai - Bhupendar Singh and Sakhi (Budruk) - Nahate.

A farmer's income typically comes from multiple sources, including cultivating his own land, farming leased land, working as an agricultural laborer, and performing various other tasks in the fields. moneylenders, landowners, and traders often act as informal financial patrons for farmers, providing much-needed credit, particularly during critical agricultural periods such as the sowing season. However, this support frequently comes at a steep cost. Moneylenders typically charge exorbitant interest rates, trapping farmers in cycles of debt. When farmers are unable to repay on time, they are sometimes coerced into selling their produce to these patrons at unfairly low prices or accepting other exploitative conditions. As a result, many small-scale farmers remain financially vulnerable and dependent on these informal networks, lacking access to more equitable sources of credit.

In addition to relying on informal credit from moneylenders and traders, many farmers also obtain loans from formal financial institutions such as banks and self-help groups (*bachat gats*) to cover the various inputs required for agricultural production. These inputs include seeds, fertilizers, pesticides, and equipment. Another common source of credit is the *Krishi Kendra* (agricultural center), where farmers often purchase seed packets and other supplies on credit rather than making immediate payments. This practice allows them to access essential inputs in time for sowing, but also adds to their financial liabilities, especially if the harvest does not yield expected returns.

When it comes to selling of their crops, many farmers prefer dealing with local brokers or traders rather than selling to government procurement agencies - even though the government often offers a higher minimum support price (MSP). This preference is largely driven by the issue of delayed payments from the government, which can take 15 to 20 days to be processed and are deposited directly into the farmers' bank accounts. In contrast, brokers and traders offer immediate cash payments, which are more appealing to farmers who often face urgent financial needs. For many, immediate liquidity outweighs the benefit of a slightly higher price, especially in the absence of strong financial buffers or reliable access to banking services.

There is a distinct gender specific division of labour exists in the production system. Women typically handle tasks such as the application of fertilizers, while men are responsible for more physically demanding activities like spraying insecticides, pesticides, and herbicides. This division contributes to a disparity in wages. Women's work, though essential, is often undervalued and considered less intensive. As a result, they are paid significantly less - around Rs. 200/- per day - compared to men, who earn Rs. 400/- per day for spraying activities and Rs. 300/- for other types of fieldwork entrusted to crop production. This wage gap highlights persistent gender inequality within rural agricultural labour.

Table 3.10. Leased amount categories (N: 74)

Amount earned (in Rs.) from leasing out agricultural land (during 01/01/2024 – 31/12/2024)	Number of Households	Percentage (%)
< Rs. 5,000/-	**1**	**1.35**
Rs. 5,001/- -10,000-	**13**	**17.57**
Rs. 10,001/ - 15,000/-	**12**	**16.22**
Rs. 15,001/ - 20,000/-	**9**	**12.16**
Rs. 20,001/ - 25,000/-	**5**	**6.76**
Rs. 25,001/ - 30,000/-	**7**	**9.46**
Rs. 30,001/ - 35,000/-	**3**	**4.05**
Rs. 35,001/ - 40,000/-	**10**	**13.51**
Rs. 40,001/ - 45,000/-	**1**	**1.35**
Rs. 45,001/ - 50,000/-	**4**	**5.41**
Rs. > 50,000/-	**9**	**12.16**
Total	**74**	**100.00**

(***Note:*** Here 7 of the 81 household did not take any amount of money for leasing out agricultural land, as those households shared their lands to other landholding relatives in return of receiving of money against yield crops.)

Table. 3.10 present data on the income generated by 74 households from leasing out agricultural land during the period of one year i.e. from January 1, 2024, to December 31, 2024. Income distribution shows considerable variation across households. A significant proportion of households (33.79 %) earned between ₹. 5,001/- and ₹. 15,000/-, indicating that leasing land often results in relatively low to moderate earnings. The highest number of households (13, or 17.57 %) fell into the ₹. 5,001/-–10,000/- income bracket, followed closely by 12 households (16.22 %) in the ₹. 10,001/-–15,000/- range. On the other hand, a notable segment of households (32.43 %) earned more than ₹. 35,000/-, suggesting that while many earn modest sums, a substantial number benefit significantly from land leasing. Only a few households reported extremely low (<₹. 5,000/-) or specific high-range incomes, such as between ₹. 40,001/- and 45,000/-, with just one household in each of these brackets.

Household assets

Table 3.11. Household Assets status other land agricultural land (N: 1051)

House Type	Number of Households (%)
Pucca House	478 (45.48)
Semi-Pucca House	195 (18.55)

Kutcha House	378 (35.97)
Total	1051 (100)
Living Rooms	
1 Room only	106 (10.09)
2 Rooms	643 (61.18)
3 Rooms	191 (18.17)
>3 Rooms	111 (10.56)
Total	1051 (100)
Household assets other than agricultural land	
Two wheelers	276 (26.01)
Tractor	9 (0.85)
Pump set for irrigation	66 (6.22)
Power tillers	15 (1.41)
Draught animals	366 (34.5)
Milching animals	285 (26.86)

(***Note:****(i)* 10 households did not own any house except staying shared leaving spaces of the house hold owner. (ii) Except for three family, which own two houses, all others have reported owing only one house for their leaving.)

Among the 1,051 surveyed households, the data reveals a diverse range of housing types, reflecting varying levels of economic stability, access to infrastructure, and durability of shelter (3.11).

Pucca houses made of permanent materials such as cement, concrete, bricks and RCC comprise 45.48 % (478 households). This is a positive indicator, suggesting that nearly half of the population has access to structurally durable and weather-resistant housing. These houses were found durable, well ventilated, and hygienic.

Kutcha houses, which are typically built with temporary or semi-durable materials like mud, thatch, bamboo, or unburnt bricks, account for 35.97 % (378 households). This is a significant proportion, highlighting a sizable segment of the population still living in vulnerable housing conditions, often prone to damage from monsoons, wind, or seasonal flooding. These houses usually lack proper insulation, ventilation, and sanitation.

Semi-pucca houses represent 18.55 % (195 households) and are constructed with a mix of temporary and permanent materials (e.g., brick walls with thatched or tin roofs). These structures indicate economic constraints limit complete structural upgrades but show signs of progress.

Number of living rooms in a household offers valuable insights into space availability, living standards and overcrowding. Most of the houses have consisted with two rooms61.18 % or 643 households). More than three rooms were found comparatively less common (10.56%) among the farmers.

Asset ownership data (Table. 3.12) reflects the material foundation of agricultural practices and household mobility in the surveyed region. Among the various assets recorded, draught animals are the most widely owned, with 34.50 % of households reporting their use. This high percentage indicates a strong dependence on traditional farming techniques, particularly for ploughing, transportation of goods, and sometimes even irrigation. The continued use of animal labour suggests that mechanization is still limited in this region, likely due to small landholdings, financial constraints, or terrain unsuited to machinery.

Closely following, milching animals are owned by 26.86 % of households, underscoring the importance of livestock rearing for dairy production, subsistence nutrition, and supplemental income. These animals often play a dual role in household economy providing daily sustenance as well as a means of economic resilience, especially in female-headed or low-income households.

Two-wheelers, primarily motorcycles or scooters, are owned by 26.01 % of households, indicating moderate personal mobility. This form of transport is essential for commuting to markets, accessing health services, or traveling to nearby work sites, especially in rural or semi-urban settings where public transport is limited. Ownership of two-wheelers often correlates with better access to infrastructure and rising economic aspirations.

Ownership of irrigation pump sets is reported by 6.22 % of households, reflecting a limited but crucial investment in water management for farming. Such low figure suggests that most farmers still rely on rainfall or communal irrigation systems, potentially affecting crop intensity and diversification. Mechanized farming tools like power tillers (1.41 %) and tractors (0.85 %) are owned by a few households.

Data points to a predominantly low-capital agrarian economy, where traditional tools like draught animals and livestock remain central to livelihoods. There is limited diffusion of modern agricultural technology such as tractors and power tillers, reflecting constraints in land size, affordability, or infrastructure. Moderate ownership of two-wheelers is a positive sign of improving rural connectivity and access to services. Low rate of irrigation equipment ownership underlines the vulnerability of agriculture to climate variability and highlights the need for better water infrastructure.

Household income

Table 3.12. Yearly Household income (N: 1061)

Category(in Rs.)	**Number of Households**	**%**
0-25,000	8	0.75
25,001-50,000	55	5.18
50,001-75,000	128	12.06
75,001-1,00,000	294	27.71
1,00,001-1,25,000	149	14.04
1,25,001-1,50,000	136	12.82
1,50,001-1,75,000	69	6.50
1,75,001-2,00,000	77	7.26
2,00,001-3,00,000	86	8.11
3,00,001-4,00,000	27	2.54
4,00,001-5,00,000	15	1.41
>5,00,000	17	1.60
Total	1061	100.00

Annual income distribution (Table. 3.13) of 1,061 households during survey reflects a predominantly lower-middle to middle-income rural profile**,** with only 1.6 % earning over ₹500,000/- annually. Most common income bracket is ₹75,001/-–100,000/-, encompassing 27.7 % of households. Another significant chunk (26.88 %) falls within ₹50,001/-–75,000/- and ₹100,001/-–150,000/-, respectively together making up to 26.9 % of households. Over 60 % of households earn between ₹50,000/- and ₹150,000/-, indicating modest economic stability backed by agriculture, livestock, or wage labour. Smaller proportions earn less than ₹50,000/- (totaling 6 %), and only 12 % report incomes above ₹150,000/-. Very low proportion (1.6 %) earning above ₹500k reveals limited high-income households in this region.

Table 3.13. Yearly Per capita Household income (N: 1061)

Category (in Rs.)	**Number of Households**	**%**
0-5,000	0	0.00
5,001-10,000	19	1.79
10,001-15,000	78	7.35
15,001-20,000	179	16.87
20,001-25,000	195	18.38
25,001-30,000	145	13.67

30,001-35,000	101	9.52
35,001-40,000	82	7.73
40,001-45,000	51	4.81
45,001-50,000	76	7.16
50,001-75,000	83	7.82
75,001-1,00,000	33	3.11
1,00,001-2,00,000	15	1.41
>2,00,000	4	0.38
Total	**1061**	**100.00**

Distribution of yearly per capita income across the 1,061 surveyed households reveals a deeply stratified and economically constrained rural society, marked by low income, limited mobility, and entrenched poverty. A significant proportion of the population is clustered around the lower-middle income brackets, with most households reporting annual per capita incomes between ₹15,001/- and ₹30,000/-. Specifically, 16.87 % of households fall within the ₹15,001/-–₹20,000/- category, 18.38 % within ₹20,001/-–₹25,000/-, and another 13.67 % within ₹25,001/-–₹30,000/-. Together, these three brackets encompass nearly half the surveyed population (48.92 %), suggesting that most individuals live on less than ₹2,500 /-per month, which is barely enough to meet subsistence needs in a rural Indian context. Such income levels, especially when considered per capita, reflect extreme constraints in disposable income, restricting access to adequate nutrition, healthcare, education, and other essential services.

Even the slightly higher income brackets show only modest improvement. For instance, only 9.52 % of households fall into the ₹30,001/-–₹35,000/- range, while 7.73 % earn ₹35,001/-–₹40,000/-, and 7.16 % fall between ₹45,001/-–₹50,000/-. Despite slight progression, these figures indicate that nearly 75 % of households earn below ₹50,000/- per person per year, pointing to a highly compressed income spectrum dominated by low-income rural households. Above this line, the percentages diminish rapidly—only 7.82 % of households earn between ₹50,001/- and ₹75,000/-, 3.11 % earn ₹75,001/-–₹1,00,000/-, and a mere 1.41 % report earnings between ₹1,00,001–₹2,00,000. At the uppermost tier, only four households, or 0.38 % of the population, earn over ₹2 lakh per capita annually, suggesting a negligible affluent segment and a near-total absence of rural elites or high-income professionals.

These patterns become even starker, when placed in the broader context of state and national economic indicators. Maharashtra, one of India's most economically advanced states, reported a per capita Net State Domestic Product (NSDP) of ₹3.09 lakh for the year 2024–25

(Government of Maharashtra, 2024). Even when adjusting for rural–urban disparities, rural Maharashtra's per capita income is estimated to be between ₹1.3 to ₹1.5 lakh annually still four to five times higher than what most households in the present study earn. Nationally, the Government of India reported a per capita Net National Income (NNI,) of ₹1.72 lakh per annum in 2022–2023(Government of India, 2023), a figure that continues to rise with urbanization, industrial growth, and rising wages in the formal sector. In contrast, over 95 % of households in the current dataset earn less than ₹1 lakh per capita annually, with over 80 % earning less than half the national average.

Compared to the rural income benchmarks derived from the NABARD All India Rural Financial Inclusion Survey (NAFIS, 2018) and NSSO reports (2014), which peg the average rural per capita income at approximately ₹46,000–₹50,000 annually, it becomes evident that over 60 % of the surveyed households are earning 40–60 % below the rural Indian mean.

Implications of this income profile are multidimensional. At the household level, low per capita income directly correlates with under nutrition, delayed healthcare-seeking behavior, high school dropout rates, and poor sanitation outcomes. Families earning ₹2,000/-–₹3,000/- per month per capita are unlikely to invest in health insurance, preventive care, or private schooling; instead, they rely heavily on overstretched public services and debt during crises.

CHAPTER 4

CULTIVATION PRACTICES - CHANGES AND CONSEQUENCES

During intensive household survey among tribal farmers in Kelapur, it was reported that current agricultural practices follow traditional (food crops) and contemporary (cash crops) ways simultaneously. One of the most evident forms of continuity is the persistence of traditional crop varieties, such as *jowar*, cotton, *tur*, and *moong* (green gram) have been cultivated in the studied villages for generations and is being continued. Though cotton cultivation in this area has been practiced for generations but nowadays mordenization is adopted for production. Cotton continues to be a dominant crop of the region. Different varieties of cotton have been introduced over the years.

However entire agricultural operation in this area is rain-fed. Monsoon plays a very crucial role in the agricultural calendar in the region. Farmers still follow traditional sowing and harvesting schedules aligned with the rainy season. During focused group interviews with farmers, it was reported that in earlier times, the monsoon being the primary source of water, farmers were able to cultivate various crops like *urad*, *moong*, *jowar*, and even paddy by solely relying on rainfall. However, the scenario has changed considerably in the recent years. Rainfall has become erratic and less dependable. As a result, only those farmers, who could access to irrigation through well, bore wells or canal systems only now able to cultivate crops like paddy, wheat, *jowar* and gram of theirs' expectations.

Erratic climatic conditions compelled to modify crop cultivation pattern to a large extent. Shift from the use of indigenous seeds to hybrid seeds is became an inevitable practice Yesteryears, farmers would save a portion of the seeds from their own harvests to sow in the following farming season. These seeds were treated with cow-dung, which acted as a natural preservative and stored in earthen pots to maintain their viability. Today, however, this technique of preservation has been lost and farmers largely depend on purchasing seeds from commercial supplies (Krishi Seva Kendra). Introduction of Bt cotton was initially seen as a technological breakthrough thus once promised pest resistance and higher yields. However, over time, new pests and pest resistance emerged, reducing its effectiveness. Simultaneously, there is also changes in crop cycle that reported by the farmers. Crops which used to be produced in winter are now being produced in summer. In the earlier times, groundnut was cultivated in the rainy season, now it is cultivated in summer.

Inter-cropping and mixed cropping are the current trend, where farmers adopt multiple varieties of crops in the same field to optimize land use for livelihood. For instance, in the studied area, *tur* is often intercropped with cotton or *jowar*. Cotton crop is interspersed with *tur*. Usually 4, 6 or 8 lines (referred to as *taas* in Marathi) of cotton are followed by one line (*taas*) of *tur* crop. This is done to increase productivity and for maximum economic return at the end of the season.

Apart from above mentioned qualitative aspects, this study also paid an intensive look in quantification of the degree and dimensions of the changing agricultural scenario of Kelapur. This chapter provides a detailed account of evolving cultivation practices, drawing from household-level data in Kelapur taluka of Yavatmal district, and establishes context for understanding their broader ecological and epidemiological implications. The household agricultural landholding status of the Kelapur block has already been discussed in length in the previous chapter. It is revealed that out of 1061 surveyed tribal farmer households, more than one-third (about 37.32 %) of the tribal households were landless, and the rest of the other (62.68 %) households had possession of cultivable land with various ranges. This study investigates the occupational engagement of landholding agricultural households in cultivating various crops over time since 1986, aiming to understand temporal changes in crop cultivation patterns in the Kelapur taluka of Yavatmal district.

Changes in cultivation patterns are important to understand because they affect not only crop production but also are associated with the socio-economic condition of cultivators, their health and food culture. The present chapter is to delineate changing cultivation practices over time and consequences in community health among tribal households in Kelapur taluka.

TABLE 4.1. TEMPORAL CHANGES IN CROP CULTIVATION PATTERN

YEAR	HOUSEHOLDS: (N= 665)								
	Crop varieties adopted for Cultivation								
	FOOD CROP							CASH CROP	
	Cereal			*Pulse*			*Oil Seed*	*Non-food crop*	*Oil Seed*
1986-1990	Jawar (6.28)	Paddy (0.48)	Bajra (0.64)	Tur (95.16)	Mung (0.48)	Urad (0.48)	Sesame (0.32)	Cotton (96.29)	**
1991-1995	Jawar (6.6)	Paddy (0.48)	Bajra (0.64)	Tur (95.16)	Mung (0.48)	Urad (0.48)	Sesame (0.32)	Cotton (96.29)	**
1996-2000	Jawar (6.6)	Paddy (0.32)	Bajra (0.48)	Tur (95.16)	Mung (0.81)	**	Sesame (0.32)	Cotton (96.29)	**
2001-2005	Jawar (7.78)	Wheat (6.92)	**	Tur (95.16)	Mung (0.32)	**	**	Cotton (96.29)	Soyabean (5.96)
2006-2010	Jawar (6.93)	Wheat (6.92)	**	Tur (95.16)	Chana (1.13)	**	**	Cotton (96.29)	Soyabean (5.96)
2011-2015	Jawar (6.93)	Wheat (6.92)	**	Tur (95.16)	Chana (1.13)	**	**	Cotton (96.29)	Soyabean (5.96)
2016-2020	Jawar (5.96)	Wheat (6.44)	**	Tur (95.16)	Chana (1.13)	**	**	Cotton (96.29)	Soyabean (5.96)
2021-2024	Jawar (5.8)	Wheat (6.28)	**	Tur (95.16)	Chana (1.13)	**	**	Cotton (96.29)	Soyabean (5.96)

Table 4.1 shows that the tribal agricultural households of Kelapur taluka (Yavatmal district) have been cultivating *tur* (*Cajanus cajan*) and cotton (*Gossypium sp*.) for more than four decades. A survey carried out by the Anthropological Survey of India in 1965 had documented that "*…Jowar and Tuor, the two main field products, which are cheaply grown by all cultivators, and these two items often form the cheap marketable commodities. Cotton is the most important cash crop of the area. Even a petty cultivator grows some amount of cotton to have cash. Til and groundnut, if produced, are meant for sale only* (Hazra, 1983)." This study is the testimony of the earlier cash crop cultivation pattern in the Yavatmal district of the Vidarbha region.

Present study reveals remarkable changes in the choice of crop varieties among 665 tribal households, who possess cultivable lands for agricultural production in 1986 (Table 4.1.). The agricultural economy of tribal households in this area mainly revolves around cash crops such as cotton (95.16 % of households) and pulses like tur (96.29 % of households) for a prolonged period. Cereal crops were practiced in low scale. Among cereals except *jawar* (sorghum), paddy and *bajra* were discarded from cultivators' choice from sometime in 2000, though these two varieties had a contribution to the staple diet of the local tribes, and now wheat occupies in cereal crops along with *jawar* in this area.

A predominant cropping pattern characterized by intercropping of legumes (*tur*) and cotton cultivation among surveyed households all through four decades has been reported in this study. However, a notable shift was observed in the diversification of food crops between 1991 and 2000, with a slight but increased trend of adoption of *mung* (0.81 % households), *bajra* (0.64 % households), and *urad* (0.48% households) in cultivation practices among tribal households. There was a marked introduction and rise in the cultivation of wheat, *chana*, and *jawar* (*sorghum*) in crop field aligning with broader regional trends of food crop revival, possibly prompted by climatic or policy shifts from 2001 onwards in this area Soybean entered the cropping system in post-2005 as a profitable oil seed by choice, is being maintaining a stable presence (5.96 % households) in crop field thereafter. Meanwhile, traditional minor cereals and pulses like paddy, *bajra*, Sesame, and *urad* had declined after the 2000s, indicating a gradual erosion of crop diversity in favor of more agrochemical-based and more lucrative cultivation practices.

TABLE 4.2. CROP VARIETIES AND AREA OF SOWN (N: 665)

Area under Cultivation (in Acre)	**HOUSEHOLDS (%)**						
	FOOD CROP				**CASH CROP**		***Total farmers (%) with Agricultural land***
	Cereals		**Pulses**		**Non-edible**	**Oil seed**	
	Jowar	***Wheat***	***Tur***	***Chana***	***Cotton***	***Soyabean***	
1-5	4.19	5.96	95	0.97	75.68	5.64	70.68
5.1-10	0	0.32	0.16	0.16	16.59	0.16	20.75
10.1-15	0.16	0	0	0	2.9	0.16	6.02
15.1-20	0	0	0	0	0.48	0	1.5
20.1-45	0	0	0	0	0.32	0	1.05
Total	5.8	6.28	95.16	1.13	96.29	5.96	100

Current crop distribution according to landholding sizes reveals a sharp diversity of crop cultivation practices among marginal and small farmers (1–5 acres), who comprise the majority of agricultural households (70.68 %). Though these households have been engaging cultivation of cotton and *tur* for about four decades but because of a paucity of sizeable land under possession, they have also continued to cultivate cereal crops and pulses to ensure food security. Among small farmers, *tur* dominates with 95 %, along with by modest engagement in *jowar* (4.19 %), Wheat (5.96 %) for self-sufficiency in food resources at household level. As landholding size increases, the proportion of food crops such as *tur* and wheat sharply decline, whereas proportion of cotton cultivation exhibits a steady, albeit reduced, presence in larger holdings. Notably, cotton continues to appear across all land brackets, up to 40 acres, indicative of its profit viability across scales. Small-scale presence of soybeans in smaller land brackets (up to 15 acres) suggests a supplementary rather than principal crop. Crops like *chana* (black gram) and *jowar (*sorghum) are almost exclusively cultivated within the smallest landholding category, reflecting their subsistence role. Overall, the data underscores the mono-crop dependence on cotton among all categories of landowners, reinforcing the vulnerability of the agro-economy to crop-specific market and climatic instabilities.

As land size increases, crop diversity and cultivation decline sharply, highlighting a skewed distribution, where larger holdings are few and underutilized. This pattern underscores the dependence of small landholding farmers on a narrow set of crops, particularly a pulse (*tur*) and a cash crop (cotton), reflecting both market-driven choices and subsistence needs.

TABLE 4.3. PERCENTAGE DISTRIBUTION OF HOUSEHOLD MEMBERS' EXPOSURE TO AGRO-CHEMS & EXPERIENCES TO HEALTH CONSEQUENCES

Age group of Farmer	Sex	Chemical Fertilizers			Pesticides			Weedicides/ Herbicides			Popular Agro-chemicals		
		Adverse health consequences			*Adverse health consequences*			*Adverse health consequences*			*Adverse health consequences*		
		Minor	**Major**	**No**	**Minor**	**Major**	**No**	**Minor**	**Major**	**No**	**Minor**	**Major**	**No**
15-49	Male	0.0	0.0	0.0	17.4	1.3	18.7	17.4	1.3	18.7	34.8	2.6	37.4
	Female	2.3	0.7	3.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.7	3.0
	Total	2.3	0.7	3.0	17.4	1.3	18.7	17.4	1.3	18.7	37.1	3.3	40.4
50-64	Male	0.0	0.0	0.0	5.5	0.9	6.4	5.5	0.9	6.4	11.0	1.8	12.8
	Female	0.9	0.6	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.6	1.5
	Total	0.9	0.6	1.5	5.5	0.9	6.4	5.5	0.9	6.4	11.9	2.4	14.3
65+	Male	0.0	0.0	0.0	5.0	0.2	5.2	5.0	0.2	5.2	10.0	0.4	10.4
	Female	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
	Total	0.0	0.2	0.2	5.0	0.2	5.2	5.0	0.2	5.2	10.0	0.6	10.6
Total		3.2	1.5	4.7	27.9	2.4	30.3	27.9	2.4	30.3	59	6.3	65.3

The present study found that cultivation practices in the Kelapur taluka (Yavatmal district) is highly intensified for decades. Simultaneously, cultivators are highly exposed to different varieties of agrochemicals, including chemical fertilizers, pesticides, weedicides /herbicides for bumper production as well as crop protection. During the survey, cultivators were reported to be experienced with different types of health issues in various degrees and intensities, because of their exposure to agrochemicals. This study made two distinct categories of illness , minor health issues and major health issues, based on the cultivator's self-reported problems. A minor or temporary health problem is categorized as one that persists for a few hours to a few days, with minimal impact on daily activities and medical interventions, for instances headache, rash/irritation on skin, opaque vision, drowsiness, etc., are categorized under 'minor' health consequences. Major/serious health problems denote those that have persisted for ten days or more and require a doctor's consultation with severely hampering daily activities, e.g., blindness, paralysis, cancer, kidney stone, etc., are categorized under 'major' health issues. Although this study also came accross many cultivators, who never had experienced with any health issues, while handling agro chemicals.

This study identified a total of 3744 adult cultivators (aged 15 years and above) that comprises 1,959 males and 1,785 females, indicating a slightly male-dominated participation in the agricultural field. They were divided into three categories, according to their physiological capabilities to perform cultivation activities in the field. Among males, the largest age group is 15–49 years, accounting for 1,390 individuals, followed by 395 in the 50–64 age group, and 174 aged 65 and above. Similarly, the female population is concentrated in the 15–49 age range with 1,300 individuals, while 363 women fall within the 50–64 bracket, and 122 are aged 65 and above. This distribution highlights a predominantly young and working-age rural population actively engaged in cultivation or allied activities.

Table 4.3. reveals a stark gender disparity in exposure to agrochemicals and the resultant health consequences among tribal households. Male farmers in their most productive age group (15–49 years) reported the highest levels of minor pesticide-related effects (17.4 %) and agrochemical-induced symptoms (34.8 %), with 1.3 % also reporting major health issues that required medical intervention. In contrast, female respondents in the same age group recorded markedly lower exposure (e.g., 2.3 % with minor and 0.7 % with major effects), suggesting limited direct involvement in agrochemical application or field spraying.

This gendered pattern is also substantiated with information collected through focus group discussions (FGDs) with cultivators of Kelapur taluka. It revealed that there is distinct gender role in division of labour among cultivators, where male participants were reported to be primarily responsible for agro-chemical handling in crop fields, and were directly exposed, particularly during spraying and weeding periods, while women were mostly engaged in seed sorting and sowing, post-harvest processing their participation in agricultural field. As a result, women reported experiences with the least adverse effects of direct contact with chemical agents but are not entirely insulated from indirect exposure via application of fertilizers, contaminated clothing, equipment, field operations, and domestic storage of agrochemicals.

Among older males (50–64 years), the pattern persists with 5.5 % reporting minor effects from pesticides, while 11 % noted minor health consequences from broader agrochemical use. Even in the elderly group (65+), 10 % of respondents reported persistent symptoms, pointing toward prolonged exposure histories, whereas female respondents above 50 years reported a very low exposure and health consequences.

Instant health consequences of using agro chemicals:

Farmers have reported experiencing a wide range of health issues after spraying chemical pesticides on their crops. Common symptoms include dizziness, nausea, abdominal pain, vomiting, skin-related conditions such as itching and fungal infections, difficulty in breathing, eye irritation, headaches, and loose motions. In some cases, swelling in the arms and legs has also been observed. More severe and long-term exposure to toxic or improperly handled pesticides has led to serious neurological problems, including difficulty in walking and, in extreme cases, partial or complete blindness. These health effects vary depending on the type and toxicity of the pesticide used, as each chemical can trigger different physiological reactions.

TABLE 4.4. PERCENTAGE DISTRIBUTION OF FARMER'S EXPERIENCES WITH INSTANT HEALTH CONSEQUENCES OF USING AGRO-CHEMICALS

Perceived Health Consequences	Sex	Chemical Fertilizers				Pesticides				Weedicides/ Herbicides				Popular Agro chemicals			
		15-49	*50-64*	*65+*	*Total*	*15-49*	*50-64*	*65+*	*Total*	*15-49*	*50-64*	*65+*	*Total*	*15-49*	*50-64*	*65+*	*Total*
Irritations/ burning eyes	**Male**	0	0	0	0	9.7	13.3	3.6	26.6	9.7	13.3	3.6	26.6	19.4	26.6	7.2	53.2
	Female	1.3	2.4	2.3	6.0	0	0	0	0	0	0	0	0	1.3	2.4	2.3	6.0
	Total	1.3	2.4	2.3	6.0	9.7	13.3	3.6	26.6	9.7	13.3	3.6	26.6	20.7	29	9.5	59.2
Opaque vision	**Male**	0	0	0	0	0.13	0.78	0	0.91	0.13	0.78	0	0.91	0.26	1.56	0	1.82
	Female	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0.13	0.78	0	0.91	0.13	0.78	0	0.91	0.26	1.56	0	1.82
Persistent cough	**Male**	0	0	0	0	0.52	0.31	0	0.83	0.52	0.31	0	0.83	1.04	0.62	0	1.66
	Female	0.22	0	0	0.22	0	0	0	0	0	0	0	0	0.22	0	0	0.22
	Total	0.22	0	0	0.22	0.52	0.31	0	0.83	0.52	0.31	0	0.83	1.26	0.62	0	1.88
Breathing trouble/Suffocation	**Male**	0	0	0	0	0.52	2.4	0.90	3.82	0.52	2.4	0.90	3.82	1.04	4.8	1.8	7.64
	Female	0.26	0	0	0.26	0	0	0	0	0	0	0	0	0.26	0	0	0.26
	Total	0.26	0	0	0.26	0.52	2.4	0.90	3.82	0.52	2.4	0.90	3.82	1.3	4.8	1.8	7.9
Drowsiness	**Male**	0	0	0	0	0.04	0	0	0.04	0.04	0	0	0.04	0.08	0	0	0.08
	Female	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0.04	0	0	0.04	0.04	0	0	0.04	0.08	0	0	0.08
Headache	**Male**	0	0	0	0	4.4	7.7	3.6	15.7	4.4	7.7	3.6	15.7	8.8	15.4	7.2	31.4
	Female	1.2	1.6	0	2.8	0	0	0	0	0	0	0	0	1.2	1.6	0	2.8
	Total	1.2	1.6	0	2.8	4.4	7.7	3.6	15.7	4.4	7.7	3.6	15.7	10	17	7.2	34.2
Vomit	**Male**	0	0	0	0	0.74	0.78	0.90	2.42	0.74	0.78	0.90	2.42	1.48	1.56	1.8	4.84
	Female	0.04	0.16	0.45	0.65	0	0	0	0	0	0	0	0	0.04	0.16	0.45	0.45
	Total	0.04	0.16	0.45	0.65	0.74	0.78	0.90	2.42	0.74	0.78	0.90	2.42	1.52	1.72	2.25	5.49
Weakness /loss of energy	**Male**	0	0	0	0	4.4	6.4	3.2	14.0	4.4	6.4	3.2	14.0	8.8	12.8	6.4	28.0
	Female	0.74	1.7	0.9	3.34	0	0	0	0	0	0	0	0	0.74	1.7	0.9	3.34
	Total	0.74	1.7	0.9	3.34	4.4	6.4	3.2	14.0	4.4	6.4	3.2	14.0	9.54	14.5	7.3	31.34
Loss of appetite	**Male**	0	0	0	0	0.04	0	0	0.04	0.04	0	0	0.04	0.08	0	0	0.08
	Female	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0.04	0	0	0.04	0.04	0	0	0.04	0.08	0	0	0.08
Skin allergy/rashes on body/scalp	**Male**	0	0	0	0	7.7	10.2	5.9	23.8	7.7	10.2	5.9	23.8	15.4	20.4	11.8	47.6
	Female	3.0	3.0	1.4	7.4	0	0	0	0	0	0	0	0	3	3	1.4	7.4
	Total	3.0	3.0	1.4	7.4	7.7	10.2	5.9	23.8	7.7	10.2	5.9	23.8	18.4	23.4	13.2	55.0
Stomach upset/loose motion	**Male**	0	0	0	0	0.39	0.47	0.45	1.31	0.39	0.47	0.45	1.31	0.78	0.94	0.9	2.62
	Female	0.09	0	0	0.09	0	0	0	0	0	0	0	0	0.09	0	0	0.09
	Total	0.09	0	0	0.09	0.39	0.47	0.45	1.31	0.39	0.47	0.45	1.31	0.87	0.94	0.9	2.71

Table 4.4. deals with the minor health consequences who have had experiences with discomfort while they were exposed to agrochemicals during different phases of agricultural

operations. Altogether 16.9 % of males aged 50 years and above had experienced eye irritation in their eyes. Almost 27 % have also experienced irritations during the spreading of herbicides. Further substantiates the gendered impacts of agrochemical use, detailing the perceived health consequences among male and female farmers by age cohort. Male cultivators consistently reported higher incidences of nearly all symptoms, including acute effects like eye irritation (up to 26.6 %), headaches (15.4 %), breathing trouble (4.8 %), and vomiting (1.56 %). Chronic effects such as skin rashes (20.4 %) and weakness (12.8 %) were also more frequently reported in males, particularly in the 50–64 age groups, suggesting the compounding effects of long-term occupational exposures.

For instance, a few cases of health hazards among farmers would be exemplary to understand the consequences of extensive use of pesticides and fertilizers. Shri Bilas Atram (37/M, resident of Umarkhed) was an agricultural labourer, who narrated that he used to experience acute eye irritation, redness, and blurred vision within hours of exposure spraying of pesticided in cotton field. Due to lack of protective gear/face shield and delayed medical intervention, his condition aggrevated further to partial vision loss. Shri Vaman Meshram (59/M (inhabitant of Manora) was also an agricultural labour and mostly engaged in mixing and spraying of pesticides in addition to other essential agricultural activities for years. He also experienced acute eye irritation, redness, and blurred vision, as happened with Shri Bilas Atram. Innitially he was experiencing persistant blurred visison for a few months and later his case turned more worsen. In some day he filled no visison suddenly. He was worried as his other family members. He consulted PHC. After some tests at PHC, he was referred to district hospital, where he diagnosed permanent blindness. There are some more cases were coming across, where farmers had experiences different types of ocular problems among farm workers. Apart from various ocular problems after getting exposed to pesticides/insecticides, there were several cases of respiratory problems those were reported by farm workers. Amongst them Shri Sumit Kodupe (25/M) of Chimur village could be referred as an example. Sumit was earning his livelihood through wage labour in the cotton field and took care mixing and spraying of pesticides in field time to time. He experienced breathing troubles after sometimes of spraying operations. He felt heavy chest and suffocation for hours together. Since that post-spraying effects are quite known to the farmers, he never approached any traditional healers and/or consulted PHS/doctor. Most of the farm labourers belonged to economically weaker section and earned their livelihood through daily wages thus hardly encourage them to take a day or two off from filed activities and consult PHC/doctors in case of exoeriencing health issues at initial stage, before it could cause any permanent damage.

Howevr, in contrast, among female farm workers, overall, fewer symptoms were reported but they were not entirely unaffected. They reported dermatological issues like skin irritation (3 %) and headaches (1.6 %) primarily in the 15–49 and 50–64 age cohorts.

Such disparity also extends to healthcare-seeking behaviour. FGDs indicated that men were more likely to report symptoms and seek treatment due to occupational disruption, while women often get rid of discomfort with home remedies. This gender asymmetry, both in physical exposure and response to illness, underscores the need for inclusive health surveillance, awareness programs, and safer division of labour in tribal agricultural systems.

Knowlwedge-Attitude-Perceptions of Agro-chemicals uses:

There have been cases of acute spray poisoning, sometimes fatal. These are mostly associated to the lack of protective gear while spraying the chemical fertilizers. A major contributor to health hazards is the lack of protective gear (gloves, masks, goggles) and insufficient knowledge about the safe handling and storage of agro chemicals. Many farmers spray chemicals without adequate protection, increasing their vulnerability to both short-term and long-term health complications. Farmers only wrap a filthy cloth to cover nose and mouth, instead of masks, gloves, or any protection gear.

Persisting application of agro chemicals in crop fields has cause some remarkable changes in the soil environment as well as ecology with changing crop cultivation practices. In these regards farmers opined that prolonged application of chemical fertilizers has led to reduction of porosity and aeration in the soil. This affects water retention and root penetration, ultimately lowering crop yields. Compacted soil also limits microbial activity, further harming soil health. Application of fertilizers is responsible for elimination of not only targeted pests but also organisms that play crucial roles in maintaining soil health. Beneficial soil organisms such as earthworms, insects, and microorganisms are particularly vulnerable and no longer seen in the topsoil in their crop fields. Similarly, beneficial insects such as pollinators and natural pest predators are affected, disturbing ecological balances, and reducing crop productivity through loss of pollination. Agro chemicals have contributed to the decline of organic carbon in soils. Without adequate organic inputs, soil fertility has taken a hit affecting long-term agricultural sustainability. A significant amount of agro chemicals applied to fields percolates through the soil and enters groundwater and surface water bodies. Pesticides sprayed on crops also wash off during rains, contaminating water resources. They also reported that in these cotton-growing regions, repeated and indiscriminate pesticide use has led to the modified of resistant of pest species. For example, Pink Bollworm are a living menace for all the cotton growing farmers.

TABLE 4.5. FARMERS' KNOWLEDGE, ATTITUDE & PERCEPTIONS OF USING AGRO-CHEMICALS (HOUSEHOLD: 1061)

Variables	Percentage	Total Number
KNOWLEDGE		
Aware of preventive measures while using agrochemicals		
Yes, aware	66.07	701
Not aware	25.16	267
Not Answered	8.76	93
Source of awareness/knowledge		
Family and Friends	25.39	178
Neighbors and Relatives	41.94	294
Krishi Kendra	5.14	36
Education	1.43	10
Large-scale farmers	0.57	4
Company	0.57	4
Panchayat office	0.28	2
Not Answered	24.68	173
Training on safe handling of agrochemicals		
Yes	12.13	85
No	87.87	616
Not Answered	0	0
PRACTICES		
Using of gloves		
Never	60.6	643
Sometimes	3.11	33
Quite often	8.58	91
Always	17.25	183
Not Answered	10.46	111
Using of mask		
Never	33.18	352
Sometimes	4.24	45
Quite often	9.9	105
Always	42.13	447
Not Answered	10.56	112
Washing hand after handling agro-chemicals		
Never	9.05	96
Sometimes	11.59	123
Quite often	8.11	86
Always	60.6	643
Not Answered	10.65	113
Preparing of Pesticides		
Inside the house	9.99	106
Outside the house	79.36	842
Not Answered	10.65	113
Habit of having food/drink/smoke during the handling of agro-chemicals		
Yes	14.99	159
Never	74.36	789
Not Answered	10.65	113
Take a smell of the spray tank		
Yes	13.57	144

No	75.77	804
Not Answered	10.65	113
Use separate measuring cup/spoon		
Yes	78.7	835
No	10.65	113
Not Answered	10.65	113
Cautions during Spay		
Spray opposite direction the wind	13.67	145
Spray same direction the wind	75.59	802
Not Answered	10.74	114
PERCEPTIONS		
Are preventive measures worth sufficiently?		
Yes	48.35	513
No	20.83	221
Not Answered	30.82	327
Changes in Soil Fertility		
Improved	19.13	203
Degraded	54.95	583
No Change	25.92	275
Changes in Crop yield		
Improved	42.6	452
Degraded	42.32	449
No Change	15.08	160
EFFECTS OF AGRO-CHEMICALS		
Chronic Health problems in the family		
Yes	45.43	482
No	28.75	305
Not Answered	25.82	274
Soil degradation		
Yes	48.07	510
No	26.11	277
Not Answered	25.82	274
Frequent pest infestations		
Yes	16.68	177
No	57.49	610
Not Answered	25.82	274
Degradation in the water retention capacity of soil		
Yes	19.51	207
No	54.67	580
Not Answered	25.82	274
Changes in test of drinking water sources		
Yes	14.42	153
No	83.6	887
Not Answered	1.98	21
Changes in the colour of drinking water sources		

Yes	1.13	12
No	97.55	1035
Not Answered	1.32	14
Water bodies are not good for having a bath		
Yes	92.93	986
No	5.75	61
Not Answered	1.32	14

Table 4.5 provides a complete assessment about the awareness levels of the tribal farmers in terms of their behavioural responses towards perceptions on adverse effects using of agrochemicals during crop cultivation. It reveals a significant knowledge-practice gap, marked by low awareness and poor protective behaviours/precautionary measures at individual level, despite their experiences with sufferings due to widespread exposure of agrochemicals.

Only 66.07 % of respondents were found aware of preventive measures while handling (mixing, preparing, and spraying) agro chemicals. Of those, who are aware – most of them aquired knowledge informally from neighbours (41.94 %) and other family members (25.39 %), while institutional knowledge sources such as Krishi Kendra (5.14 %) and the education department (1.43 %) remained insignificant in the mass-awareness programme. Formal training was received by only 12.13 % of farmers, indicating a lack of structured outreach. This has direct implications for safe handling, as reflected in the behavioural data.

Protective practices/preventive measures were inconsistently followed. For instance, 60.6 % never used gloves during handling (mixing, preparing, and spraying), and only 42.13 % consistently used masks. While handwashing after chemical handling was a well-followed habit (60.6 % marked always), other safety norms were neglected, nearly 15 % admitted to having food, drink or smoking during agro-chemical uses, and 13.57 % reported sniffing spray tanks. These behaviours sharply elevate the risk of different toxicological outcomes, as documented in studies by Mehta (2015) and Singh (2012).

Interestingly, while 78.7 % used separate measuring tools and 79.36 % prepared pesticide mixes outdoors, 75.59 % sprayed chemicals in the same direction as the wind blows, exposing themselves to drift contamination. Perceptions about preventive measures are divided -48.35 % deemed them worthwhile, while 20.83 % considered them ineffective, highlighting a need to bridge knowledge with perceived utility.

In terms of environmental perception, 54.95 % reported degradation in soil fertility and 42.32 % reported a decline in crop yield. More than 45 % of them linked chronic illnesses in their families to agrochemical exposures. Additionally, 92.93 % observed that water bodies were no longer safe for bathing, indicating awareness of ecosystem contamination.

Over the past three decades, cultivation practices in the Vidarbha region have undergone a significant transformation. Once traditional subsistence food crops, which were main agricultural outcomes, have now begun to be turned primarily into a highly intensified rain-fed cash crop production region, particularly cotton and soybean for years. These changes are driven by market forces, technological intensification, and with rising inputs of agro-chemicals, current agricultural practice has now altered cropping patterns, and declining crop diversity, as the same had already reported in some earlier works in the Vidarbha region (Wagh and Dongre, 2016; Cotton Corporation of India, 2021). Some studies reported a 30 % decline in crop diversity in this area since the 1990s, as well as a sharp increase in fertilizer, pesticide, and weedicide usages that raise concerns about long-term soil fertility and human health (Kranthi *et al.*, 2014; Reddy *et al.*, 2020). Apart from those reports, overall survey data of this study reflects a high reliance on agro chemicals that coupled with poor access to scientific knowledge and inadequate adoption of safety measures. These patterns heighten the risk of cumulative toxicity and environmental degradation in the tribal agrarian setting of the Kelapur taluka (Yavatmal district), Vidarbha region, for years as an inevitable by-product of intensified agriculture practices, thus requiring urgent attention in further.

CHAPTER 5

MORBIDITY SCENARIO IN FARMER HOUSEHOLDS

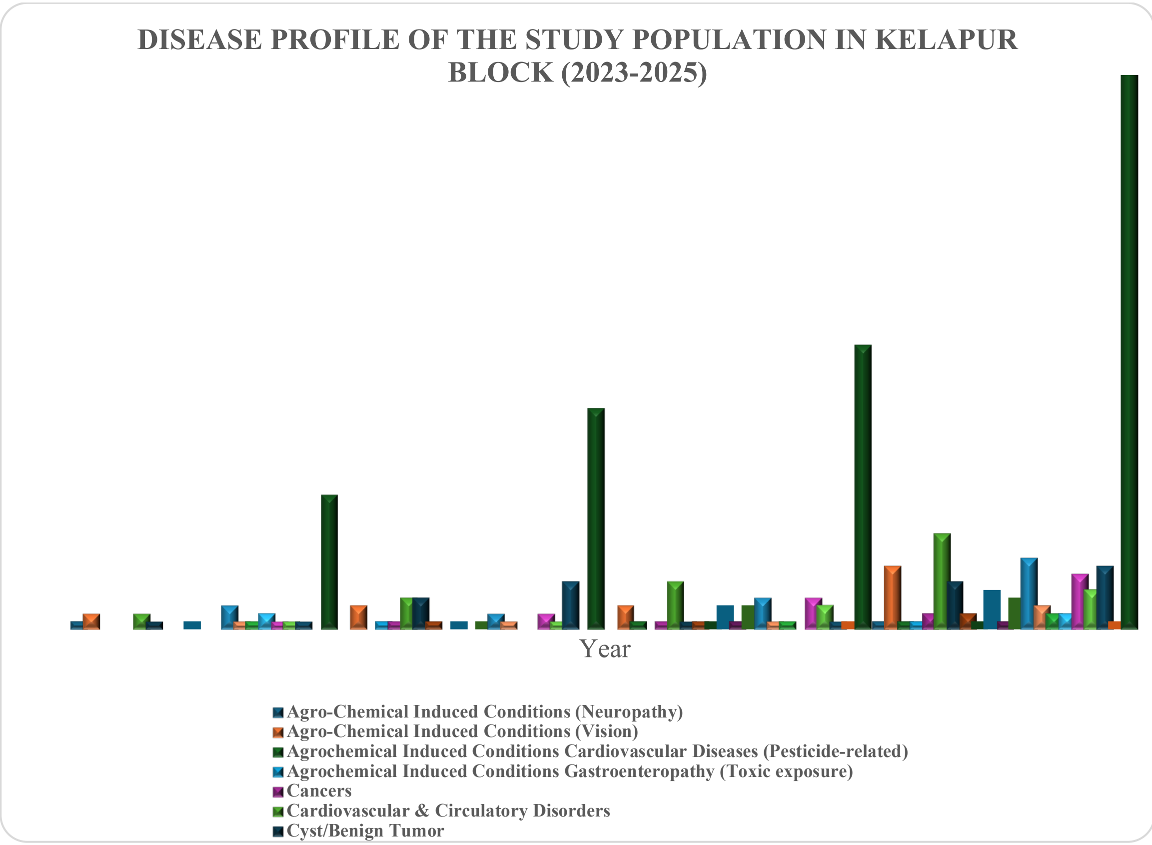
Health and morbidity trends among tribal groups have been drastically transformed in the past few decades, especially in those regions where intensive agricultural modernization has been occurring and has increasingly been a cause of concern in the context of changing cropping patterns and environmental risks. India's tribal population, which makes up about 8.6% of the country's population (104 million according to 2011 Census), experience health-related issues that are frequently aggravated by geographical remoteness, poor access to healthcare services, and accelerated socio-economic changes (Narain, 2019; Expert Committee on Tribal Health. (2014)). This chapter presents a comprehensive account of morbidity trends of tribal farmers of Kelapur Block, Yavatmal District, Maharashtra, based on data obtained from 1,061 households distributed over 25 villages with a total population of 4,601 individuals. The assessment captures complex health problems illustrating the intersection of traditional habits of existence, contemporary agricultural practices, and financial and social transformations.

Temporal Trends in Disease Prevalence (2022-2024)

TABLE 5.1. Disease Profile of the Study Population in Kelapur Block (2023-2025)

(Figures mentioned in paratheses are % value)

Fig 5.1: Disease Profile of the Study Population in Kelapur Block (2022–2024)



Disease/Illness	2022	2023	2024	Total
Agrochemical Induced Conditions (Neuropathy)	1 (1.23)	0 (0.00)	0 (0.00)	1 (1.23)
Agrochemical Induced Conditions (Vision)	2 (2.47)	3 (3.70)	3 (3.70)	8 (9.88%)
Agrochemical Induced Conditions (cardiovascular disease)	0 (0.00%)	0 (0.00%)	1 (1.23%)	1 (1.23%)
Agrochemical Induced Conditions (Gastroenteropathy)	0 (0.00%)	1 (1.23%)	0 (0.00%)	1 (1.23%)
Cancers	0 (0.00%)	1 (1.23%)	1 (1.23%)	2 (2.47%)
Cardiovascular and Circulatory Disorders	2 (2.47%)	4 (4.94%)	6 (7.41%)	12 (14.81%)
Cyst Or Benign Tumour	1 (1.23%)	4 (4.94%)	1 (1.23%)	6 (7.41%)
Dermatological Conditions	0 (0.00%)	1 (1.23%)	1 (1.23%)	2 (2.47%)
Endocrine and Metabolic Disorders	0 (0.00%)	0 (0.00%)	1 (1.23%)	1 (1.23%)
Eye and Vision Disorders	1 (1.23%)	1 (1.23%)	3 (3.70%)	5 (6.17%)
Gastrointestinal and Hepatic Disorders	0 (0.00%)	1 (1.23%)	4 (4.94%)	5 (6.17%)
Infectious and Parasitic Diseases	3 (3.70%)	2 (2.47%)	4 (4.94%)	9 (11.11%)
Musculoskeletal Disorders	1 (1.23%)	1 (1.23%)	1 (1.23%)	3 (3.70%)
Neurological Disorders	1 (1.23%)	0 (0.00%)	1 (1.23%)	2 (2.47%)
Renal and Urological Disorders	1 (1.23%)	2 (2.47%)	4 (4.94%)	7 (8.64%)
Respiratory Disorders	1 (1.23%)	1 (1.23%)	3 (3.70%)	5 (6.17%)
Sickle cellAnaemia	1 (1.23%)	6 (7.41%)	1 (1.23%)	8 (9.88%)
Animal attack Injuries	0 (0.00%)	0 (0.00%)	1 (1.23%)	1 (1.23%)
Others	2 (2.47%)	0 (0.00%)	0 (0.00%)	2 (2.47%)
Total	17 (20.99%)	28 (34.57%)	36 (44.44%)	81 (100.00%)

Table 5.1 describes the most common diseases in study population over a period of 3 years (2022-2024), providing insights into recent health trends among tribal farmers. The data reveal 81 cases under all categories of disease, the qualitative data indicates a steady increase in metabolic disorders, specifically hypertension and diabetes, which aligns with the observed cardiovascular disease burden emerging as the most common health issue with 12 cases (14.81% of total cases). Cases under directly attributable to agricultural chemical exposure is a total of 11 persons (13.25% of all diagnosed cases), predominantly affecting vision with consistent reporting across 2022-2024 and suggesting ongoing occupational exposure risks. It is then followed by infectious and parasitic diseases at 9 cases (11.11%) and sickle cell anaemia, both at 8 cases (9.88%). Renal and urological disorders accounted for 7 cases (8.64%), while cyst or benign tumours accounted for 6 cases (7.41%). The burden of disease was predominantly found in 2024, with 36 cases (44.44% of total), while 28 cases (34.57%) were found in 2023 and 17 cases (20.99%) in 2022.

Data indicate that many cases are directly related to agricultural chemical exposure. Agro-chemical vision conditions (temporary vision loss) were a persistent issue throughout the study period, with 2 cases in 2022, 3 cases in 2023 and 3 cases in 2024, totalling 8 cases (9.88%). Other pesticide induced conditions include cardiovascular effects (1 case), gastroenteropathy (1 case) and neuropathy (1 case), which reflect the multisystem effect of increased usage of agrochemicals in contemporary farming practices among the tribal population.

The spatial distribution of diseases as observed from Table 5.1, is an indication of the complicated epidemiological transition among intensive agriculture exposed tribal population. The predominance of cardiovascular disorders (14.81%) among tribal farmers represents a critical public health concern that extends beyond traditional occupational hazards. This increased cardiovascular burden is reflective of strong evidence purporting that pesticide toxic free radicals have a critical role in human health with considerable evidence showing that pesticide exposure elevates the risk for cardiovascular disease development (Sekhotha et al., 2016; Chaudhry, 2022). Farmers had a limited understanding of pesticides and were not aware of Integrated Pest Management and they also had an incomplete picture of the consequences arising from the use of pesticides (Uikey & Patil, 2024).

This is consistent with wider trends seen throughout Maharashtra, where farmers here typically go to see health centres and hospitals for medication, injections, and saline infusions in a bid to manage dizziness, vomiting and distorted vision resulting from pesticide poisoning (Kulkarni et al., 2018). The regularity of occurrence of agro chemical caused vision issues in all three years is consistent with documented evidence indicating that respiratory illnesses like cough, wheezing, rhinitis, obstructive cardiovascular conditions and tachycardia are most commonly found among farm workers (Khode et al., 2024). Earlier research has reported that problematic health effects like dizziness, cardiac ailment and other ocular symptoms are most encountered among long-term exposed agricultural labourers (Yadav et al., 2018).

In the present study, the reported sickle cell disease (SCD) and sickle cell trait (SCT) cases varied across years, with 6 cases in 2023 compared to 1 case each in 2022 and 2024. The reported cases along with secondary and qualitative data, indicate an overall comparatively low frequency of SCD and SCT.The prevalence of sickle cell anaemia is 9.88%, which indicates the genetic susceptibility of central Indian tribal groups, wherein the sickle gene is prevalent in most of the tribal population groups with heterozygote prevalence ranging between 1 and 35 percent (Colah et al., 2015). Past systematic reviews show that Madhya Pradesh, Chhattisgarh, and Maharashtra account for a high prevalence of SCD and SCT, while among tribal populations a carrier rate of 10% to 30% is found in specific areas (Rao et al., 2024).

The heterogeneity of the conditions presented from infectious diseases to metabolic disorders, cancers and organ-specific toxicities indicates that tribal farmers carry a multifaceted disease burden that goes beyond crude occupational exposure categories. Interestingly, infectious, and parasitic diseases was the second highest disease category with 9 cases (11.11%), which had an increasing trend from 3 cases in 2022 to 4 cases in 2024. Systematic reviews indicate that occupational exposure to pesticides results in higher incidence of respiratory diseases and neurodegenerative disorders, with those exposed for prolonged or high intensity duration, specifically agricultural workers, having greater chances of developing long term health impacts (Shekhar et al., 2024). Research has established that hazardous occupational exposure to organophosphate pesticides results in respiratory disease, reduced lung capacities and haematological changes among pesticide sprayers (Fareed et al., 2013). Respiratory disease accounted for 5 cases (6.17%), with a significant increase from 1 case in both 2022 and 2023 to 3 cases in 2024. The temporal clustering of cases, and specifically the peak in 2024, represents complex interactions between patterns of healthcare seeking and illness behaviour among tribal farmers (research objective 5). Studies show that about 40% of India's entire cultivated land is pesticides-treated but many farmhands are not well-equipped with all-around protective gear and information about health hazards, especially among the tribals who further challenges would have pertaining to education, earning and access to healthcare (Khode et al., 2024).

5.2. GENDER AND CAUSE SPECIFIC HOUSEHOLD MORBIDITY PROFILE AMONG FARMERS

Disease or Illness	Agricultural Labourers			Farmers			Total		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
Agrochemical Induced Conditions (Neuropathy)	0 (0.00%)	2 (5.13%)	2 (5.13%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (1.72%)	2 (1.72%)
Agrochemical Induced Conditions (Vision)	0 (0.00%)	3 (7.69%)	3 (7.69%)	0 (0.00%)	5 (6.49%)	5 (6.49%)	0 (0.00%)	8 (6.90%)	8 (6.90%)
Agrochemical Induced Conditions (cardiovascular disease)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (1.30%)	0 (0.00%)	1 (1.30%)	1 (0.86%)	0 (0.00%)	1 (0.86%)
Agrochemical Induced Conditions (Gastroenteropathy)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (1.30%)	1 (1.30%)	0 (0.00%)	1 (0.86%)	1 (0.86%)
Cancers	1 (2.56%)	1 (2.56%)	2 (5.13%)	0 (0.00%)	1 (1.30%)	1 (1.30%)	1 (0.86%)	2 (1.72%)	3 (2.59%)
Cardiovascular and Circulatory Disorders	1 (2.56%)	4 (10.26%)	5 (12.82%)	10 (12.99%)	6 (7.79%)	16 (20.78%)	11 (9.48%)	10 (8.62%)	21 (18.10%)
Cyst Or Benign Tumour	1 (2.56%)	0 (0.00%)	1 (2.56%)	4 (5.19%)	1 (1.30%)	5 (6.49%)	5 (4.31%)	1 (0.86%)	6 (5.17%)
Dermatological Conditions	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (1.30%)	2 (2.60%)	3 (3.90%)	1 (0.86%)	2 (1.72%)	3 (2.59%)
Disability Or Functional Impairment	0 (0.00%)	1 (2.56%)	1 (2.56%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.86%)	1 (0.86%)
Endocrine and Metabolic Disorders	1 (2.56%)	0 (0.00%)	1 (2.56%)	2 (2.60%)	4 (5.19%)	6 (7.79%)	3 (2.59%)	4 (3.45%)	7 (6.03%)
Eye and Vision Disorders	0 (0.00%)	1 (2.56%)	1 (2.56%)	0 (0.00%)	2 (2.60%)	2 (2.60%)	0 (0.00%)	3 (2.59%)	3 (2.59%)
Gastrointestinal and Hepatic Disorders	2 (5.13%)	1 (2.56%)	3 (7.69%)	1 (1.30%)	4 (5.19%)	5 (6.49%)	3 (2.59%)	5 (4.31%)	8 (6.90%)
Infectious and Parasitic Diseases	1 (2.56%)	1 (2.56%)	2 (5.13%)	1 (1.30%)	9 (11.69%)	10 (12.99%)	2 (1.72%)	10 (8.62%)	12 (10.34%)
Musculoskeletal Disorders	2 (5.13%)	1 (2.56%)	3 (7.69%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (5.13%)	1 (2.56%)	3 (7.69%)
Neurological Disorders	0 (0.00%)	2 (5.13%)	2 (5.13%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (1.72%)	2 (1.72%)
Renal and Urological Disorders	0 (0.00%)	4 (10.26%)	4 (10.26%)	0 (0.00%)	3 (3.90%)	3 (3.90%)	0 (0.00%)	7 (6.03%)	7 (6.03%)
Respiratory Disorders	1 (2.56%)	3 (7.69%)	4 (10.26%)	2 (2.60%)	2 (2.60%)	4 (5.19%)	3 (2.59%)	5 (4.31%)	8 (6.90%)
Sickle cell Anaemia	2 (5.13%)	1 (2.56%)	3 (7.69%)	2 (2.60%)	0 (0.00%)	2 (2.60%)	4 (3.45%)	1 (0.86%)	5 (4.31%)
Animal attack Injuries	1 (2.56%)	0 (0.00%)	1 (2.56%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (2.56%)	0 (0.00%)	1 (2.56%)
Others	1 (2.56%)	0 (0.00%)	1 (2.56%)	2 (2.60%)	1 (1.30%)	3 (3.90%)	3 (2.59%)	1 (0.86%)	4 (3.45%)

Total	14 (35.90%)	25 (64.10%)	39 (100.00%)	29 (37.66%)	48 (62.34%)	77 (100.00%)	43 (37.07%)	73 (62.93%)	116 (100.00%)

Fig. 5.2 GENDER AND CAUSE SPECIFIC HOUSEHOLD MORBIDITY PROFILE AMONG FARMERS

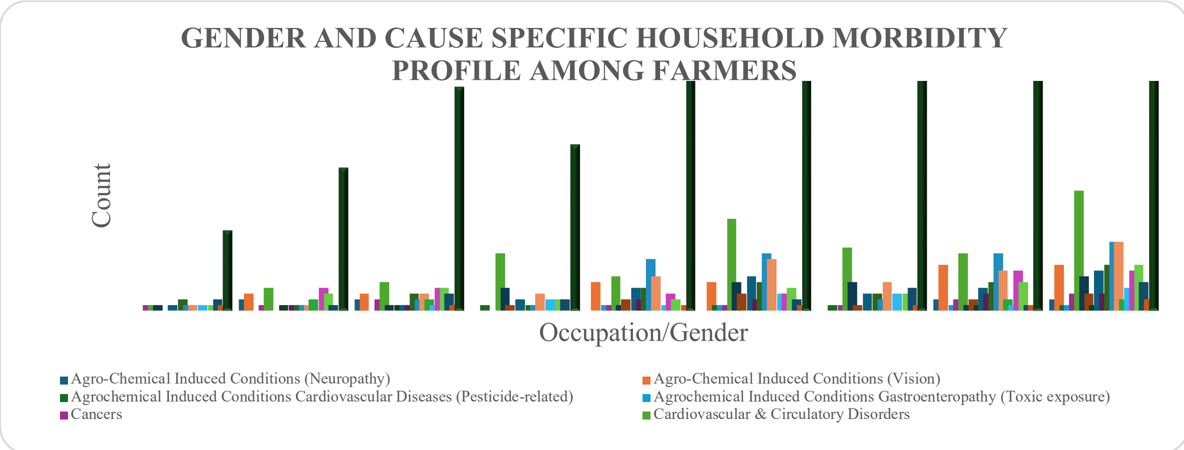


Table 5.2 explains overall morbidity by sex among 116 cases diagnosed (both farmers and agricultural labourers). The data present wide gender differences in the pattern of disease with a total of 62.93% of the cases being males and 37.07% females. Cardiovascular and circulatory disorders are the most occurring disease burden (18.10% of total cases) that strikes more males (8.62%) than females (9.48%). Musculoskeletal Disorders make up 7.69% of the total cases, with a high male predominance (5.13% vs 2.56% in females), possibly due to the physically strenuous nature occupation that is usually the domain of men. Yet, qualitative findings reveal that joint pain is a prevalent health complaint among adults of both genders.

Infectious and parasitic diseases account for 10.34% of all cases with significant male predominance (8.62% vs 1.72%), suggesting wider occupational or environmental risk factors which disproportionately impact men in farm environments. Agro-chemical induced conditions (vision) exhibit considerable gender differential with male predominance (6.90%) and no female cases (0.00%). This pattern is likely to be a manifestation of gendered segregation of farm labouring with higher male involvement in pesticides, insecticides and herbicides spraying, and handling. Gastrointestinal and hepatic diseases are present in 6.90% of the population with male dominance (4.31% vs 2.59%), whereas respiratory diseases involve 6.90% with equal male dominance (4.31% vs 2.59%).

Renal and urological disorders are found in 6.03% of patients, involving just males in this population. Endocrine and metabolic disorders are found in 6.03% of the population but occur at a higher proportion in males (3.45% vs 2.59%). Sickle cell anaemia is found in 4.31% of the population and is more pronounced in females (3.45%) than in males (0.86%), suggestive of gender-specific presentation or detection rates.

A few conditions have gender-specific patterns. Conditions of cyst or benign tumour predominantly afflict females (4.31% vs 0.86%), while conditions of agro-chemical induced and renal disorders show male predominance. Infections and parasitic diseases have marked male predominance, suggesting wider occupational or environmental risk factors preferentially acting on men in agricultural environments. The morbidity pattern in Kelapur reflects the double burden of infectious diseases and incipient non-communicable diseases typical of populations in epidemiological transition. Significant rate of cardiovascular diseases (18.10%) in this tribal population is noteworthy with a marginal male excess (8.62% vs 9.48%), being consistent with expected trends where cardio-vascular diseases exhibit male predominance in workplaces.

Gender differences in agro chemical caused health conditions are striking and reflect occupational exposure patterns and customary gender roles in farm work. The toxicities of pesticides have the potential to cause various vision disorders, neurological and long-term health ailments, with males suffering the initial brunt because of direct contact with these substances (Sanket Jain, 2024). Infectious and parasitic diseases at 10.34 % is in alarming state with a distinct male predominance (8.62 % vs 1.72 %) that could be indicative of work-associated exposure patterns or varied healthcare seeking practices. This is within ranges documented in tribal groups all over India, although the gender difference should be explored further.

Presence of sickle cell anaemia at 4.31% with a female predominance (3.45% vs 0.86%) concurs with documented genetic trends in central Indian tribal populations. The prevalence rates of sickle cell disease have been varied among tribal groups, with Maharashtra revealing high burden among indigenous groups (Chakma et al., 2017). The gender difference in detection can be representative of reproductive health screening behavior or healthcare utilization patterns among tribal women. On analysing the occupational breakdown, agricultural labourers contribute 33.62% (39 cases) to the total diagnosis and farmers contribute 66.38% (77 cases). Of the agricultural labourers, musculoskeletal disorders have the highest rate (10.26%), whereas among farmers cardiovascular disorders predominate (20.78%). This job difference presents varying patterns of disease exposure, with farmers recording increased rates of cardio-vascular illness potentially because of exposure to pesticides as well as stress associated with work, whereas labourers record greater musculoskeletal disorders from physical demands of work.

Life Course Perspective on Morbidity

Table 5.3. General Morbidity Profile of Respondents By Physiological Stage

Disease/Illness	Infant	Child	Young Child	Juvenile	Adult	Old	Total
Agrochemical Induced Conditions (Neuropathy)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.57%)	1 (0.57%)	0 (0.00%)	2 (1.14%)
Agrochemical Induced Conditions (Vision)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	9 (5.14%)	2 (1.14%)	11 (6.29%)
Agrochemical Induced Conditions (cardiovascular disease)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.57%)	0 (0.00%)	1 (0.57%)
Agrochemical Induced Conditions (Gastroenteropathy)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.57%)	0 (0.00%)	1 (0.57%)
Cancers	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (1.71%)	2 (1.14%)	5 (2.86%)
Cardiovascular and Circulatory Disorders	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	25 (14.29%)	10 (5.71%)	35 (20.00%)
Cyst Or Benign Tumour	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	7 (4.00%)	0 (0.00%)	7 (4.00%)
Dermatological Conditions	0 (0.00%)	1 (0.57%)	0 (0.00%)	0 (0.00%)	3 (1.71%)	1 (0.57%)	5 (2.86%)
Disability Or Functional Impairment	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (1.14%)	0 (0.00%)	2 (1.14%)
Endocrine and Metabolic Disorders	0 (0.00%)	0 (0.00%)	1 (0.57%)	1 (0.57%)	8 (4.57%)	2 (1.14%)	12 (6.86%)
Eye and Vision Disorders	0 (0.00%)	1 (0.57%)	0 (0.00%)	0 (0.00%)	4 (2.29%)	0 (0.00%)	5 (2.86%)
Gastrointestinal and Hepatic Disorders	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	10 (5.71%)	1 (0.57%)	11 (6.29%)
Infectious and Parasitic Diseases	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	16 (9.14%)	3 (1.71%)	19 (10.86%)
MusculoskeletalDisorders	1 (0.57%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	14 (8.0%)	1 (0.57%)	16 (9.14%)
Neurological Disorders	0 (0.00%)	1 (0.57%)	0 (0.00%)	2 (1.14%)	3 (1.71%)	1 (0.57%)	7 (4.00%)
Renal and Urological Disorders	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	10 (5.71%)	0 (0.00%)	10 (5.71%)
Respiratory Disorders	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	11 (6.29%)	0 (0.00%)	11 (6.29%)
Sickle cell Anaemia	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	8 (4.57%)	0 (0.00%)	8 (4.57%)
Animal attack Injuries	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (1.14%)	0 (0.00%)	2 (1.14%)
Others	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	4 (2.29%)	1 (0.57%)	5 (2.86%)
Total	1 (0.57%)	3 (1.71%)	1 (0.57%)	4 (2.29%)	142 (81.14%)	24 (13.71%)	175 (100.00%)

Fig 5.3 General Morbidity Profile of Respondents by Physiological stage

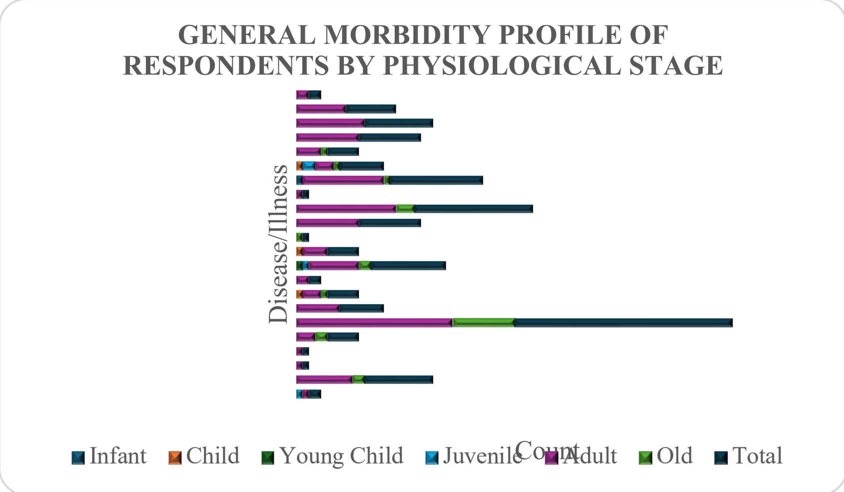


Table 5.3 presents lifecourse analysis of morbidity patterns across physiological stages, in total 175 diagnosed cases. Adults are the vast majority among diagnosed cases (81.14%), followed by the elderly (13.71%) and there is insignificant representation of younger age groups (juveniles 2.29%, children 1.71%, infants 0.57%, and young children 0.57%). The adult population carries the greatest burden of disease, with cardiovascular and circulatory disorders being most common (14.29%), followed by infectious and parasitic diseases (9.14%), musculoskeletal disorders (8.0%) and respiratory disorders (6.29%). Prevalence of occupational diseases such as agrochemical induced vision conditions (5.14%) and respiratory diseases within the working age group is a clear demonstration of occupational exposures during working life.

Among the older population, cardio-vascular disorders emerge more prominently (5.71% of all cases), reflecting progression of chronic diseases with advancing age. The occurrence of agro-chemical induced vision problems (1.14%) and cancers (1.14%) in this age group points to ageing susceptibility and perhaps cumulative action of lifetime exposure to agricultural chemicals. Child and adolescent age groups demonstrate relatively lesser disease burden, although there are worrying trends. A child was diagnosed with dermatological conditions and another with eye and vision disorders, pointing towards exposures to environmental factors during early life. The incidence of endocrine & metabolic disorders in young children (0.57%) and juveniles (0.57%) could be related to exposure to environmental contamination or nutrient deficiency. Notably, one case of agrochemical induced neuropathy was identified in the juvenile population (0.57%), indicating early occupational or environmental exposure.

Age distribution pattern indicates the occupational health risks faced by the economically active adult population engaged in agricultural activities. Prevalence of agro-chemical related health conditions in adults (5.71% of all agro-chemical conditions) supports the occupational nature of these exposures. Studies indicate that significant proportions of farmers experience pesticide poisoning yearly, with high rates reported across South Asian agricultural communities (Boedeker et al., 2020). The presence of cardiovascular disorders across age groups, including younger adults, indicates early onset of cardiovascular risk factors. High burden of cardiovascular conditions (20.00% of total cases) with predominant adult presentation (14.29%) reflects both occupational stress and lifestyle factors. Studies in tribal communities of Central India have shown similar patterns where younger populations demonstrate early development of chronic diseases (Chakma et al., 2017). Development of cardio-vascular conditions in older adults mirrors the natural history of chronic diseases but also reflects inadequately managed conditions in younger adult life.

Prevalence of sickle cell anaemia among adults (4.57% of total cases, exclusively in adult population) can be attributed to survival patterns and detection practices in tribal populations. Research among tribal populations has documented varying prevalence rates of sickle cell disease, with working age adult prevalence underscoring the socioeconomic consequences of genetic disorders among populations reliant on physical labour (Colah et al., 2015b). Relatively low paediatric disease burden (2.85% combined for all paediatric age groups) may reflect underutilization of childrens healthcare services, a characteristic pattern in tribal areas where limited access to healthcare remains a significant challenge. However, the presence of agro-chemical induced conditions and neurological disorders in younger age groups is concerning and warrants targeted intervention strategies to prevent early life exposures to agricultural chemicals (Sahu *et al.*, 2024).

Community Level Morbidity Profile

Table 5.4. Morbidity Profile of Respondents In Studied Villages

Patient Diagnosed			
Disease/ Illness	**Female**	**Male**	**Total**
Agrochemical Induced Conditions (Neuropathy)	0 (0.00%)	2 (1.14%)	2 (1.14%)
Agrochemical Induced Conditions (Vision)	1 (0.57%)	10 (5.71%)	11 (6.29%)
Agrochemical Induced Conditions (cardiovascular disease)	1 (0.57%)	0 (0.00%)	1 (0.57%)
Agrochemical Induced Conditions (Gastroenteropathy)	0 (0.00%)	1 (0.57%)	1 (0.57%)
Cancers	2 (1.14%)	3 (1.71%)	5 (2.86%)
Cardiovascular and Circulatory Disorders	21 (12.00%)	14 (8.00%)	35 (20.00%)
Cyst Or Benign Tumour	5 (2.86%)	2 (1.14%)	7 (4.00%)
Dermatological Conditions	1 (0.57%)	4 (2.29%)	5 (2.86%)
Disability Or Functional Impairment	0 (0.00%)	2 (1.14%)	2 (1.14%)
Endocrine and Metabolic Disorders	6 (3.43%)	6 (3.43%)	12 (6.86%)
Eye and Vision Disorders	0 (0.00%)	5 (2.86%)	5 (2.86%)
Gastrointestinal and Hepatic Disorders	3 (1.71%)	8 (4.57%)	11 (6.29%)
Infectious and Parasitic Diseases	5 (2.86%)	14 (8.00%)	19 (10.86%)
Musculoskeletal Disorders	7 (4.00%)	9 (5.14%)	16 (9.14%)
Neurological Disorders	2 (1.14%)	5 (2.86%)	7 (4.00%)
Renal and Urological Disorders	2 (1.14%)	8 (4.57%)	10 (5.71%)
Respiratory Disorders	4 (2.29%)	7 (4.00%)	11 (6.29%)
Sickle cell Anaemia	6 (3.43%)	2 (1.14%)	8 (4.57%)
Animal attack Injuries	1 (0.57%)	1 (0.57%)	2 (1.14%)
Others	4 (2.29%)	1 (0.57%)	5 (2.86%)
Total	71 (40.57%)	104 (59.43%)	175 (100.00%)

Fig 5.4 Morbidity Profile of Respondents in Studied Villages

Table 5.4 explains the overall morbidity pattern of studied villages, including 175 diagnosed cases where males accounted for 59.43% and females 40.57% of cases. The table presents the health conditions facing the tribal farming community.

Cardiovascular and circulatory disorders represent the most significant health problem (20.00% of total cases), with greater female prevalence (12.00%) than male (8.00%). Infectious and parasitic diseases are second on the list (10.86%), with opposite gender distribution showing greater male prevalence (8.00%) than female (2.86%). Musculoskeletal disorders are third (9.14%), primarily involving males (5.14%) with notable female representation (4.00%). Endocrine and metabolic disorders account for 6.86% of cases with equal gender distribution (3.43% each).

Study findings show an overall range of health conditions involving various cancers and tumours, metabolic, infectious, and occupational diseases. Of note, agro-chemical induced vision conditions occurred in 6.29% of the population with a strong male predominance (5.71% vs 0.57%), while renal & urological disorders were noted in 5.71% of the population, predominantly affecting males (4.57% vs 1.14%). Gastrointestinal and hepatic disorders account for 6.29% of cases with male predominance (4.57% vs 1.71%). Respiratory diseases account for 6.29% of the cases and sickle cell anaemia represents 4.57% with female predominance (3.43% vs 1.14%). The occurrence of multiple neurological disorders (4.00% of cases) suggests either environmental exposures or genetic susceptibility, with slight male predominance (2.86% vs 1.14%).

The community level morbidity profile presents a complex epidemiological scenario that represents the multifaceted health challenges facing tribal farming communities in the Vidarbha region. Cardiovascular and circulatory Disorders have an incidence rate of 20.00% with greater female prevalence than male, which contrasts with studies done in Maharashtra where prevalence of hypertension is significantly higher among men (Meshram et al., 2014b). This finding suggests unique risk factors or healthcareseeking patterns specific to tribal women in agricultural communities. High prevalence of sickle cell anaemia (4.57%) supports the genetic burden that is typical among tribal groups in central India (De et al., 2006). Rathod et al. (2017) reported similar prevalence rates in tribal communities of Yavatmal (Vidarbha), documenting sickle cell trait prevalence varying across different tribal populations in Maharashtra, Madhya Pradesh, Orissa, Chhattisgarh, and Jharkhand, which they attributed to founder effects and genetic drift in geographically isolated populations (Gorakshakar, 2006). Increased female prevalence (3.43% vs 1.14%) may reflect better healthseeking behaviour or antenatal screening practices.

High prevalence of agro-chemical induced vision conditions (6.29%) represents a critical occupational health emergency, with overwhelming male predominance (5.71% vs 0.57%). This finding concurs with research by Dhananjayan and Ravichandran (2018), which documented widespread pesticide related health effects in Maharashtra cottongrowing regions. The gender disparity reflects conventional farming practices but also points to limitations in occupational safety education and utilization of protective equipment. The 10.86% prevalence of infectious and parasitic diseases, with strong male predominance (8.00% vs 2.86%), significantly exceeds national norms and reflects the intersection of poverty, malnutrition and housing conditions typical in tribal communities. Studies conducted by Kaur et al. (2022) in tribal districts across India have shown similar trends, emphasizing socioeconomic determinants influence on disease transmission and outcomes.

The broad spectrum of cancers and tumours observed (2.86% of total cases) may reflect environmental exposures, genetic predisposition, or delayed presentation patterns. Multiple studies have documented associations between exposure to agro-chemicals and cancer development, though definitive causal relationships require further investigation (Amizadeh et al., 2017; Ataei and Abdollahi, 2022). The equal gender distribution of these conditions suggests broader environmental rather than occupational specific exposures.

In summary, the overall morbidity analysis in Tables 5.1 to 5.4 reveals a complex health profile of tribal farmers in study area, typified by the convergence of traditional health problems with rising occupational and environmental health risks. Temporal patterns show continuous exposure to pesticide chemicals, while gendered patterns demonstrate the unequal impact of occupational activities and social determinants. The temporal analysis (Table 5.1) demonstrates persistent exposure to agro-chemical hazards across 2023-2024, with cardio-vascular disorders emerging as the leading health concern, followed by sickle cell anaemia and agrochemical induced vision conditions. The concentration of disease burden in 2024 (55.38% of all cases) reflects complex healthcareseeking patterns and potential clustering of health problems in tribal farming communities.

Gendered patterns demonstrate the unequal impact of occupational activities and social determinants, with males bearing disproportionate burden of agrochemical induced vision conditions while cardiovascular disorders show unexpected female predominance. The life course approach draws attention to the cumulative health risks, with the adult population shouldering the leading disease burden from occupational and lifestyle factors. The morbidity profile at the community level provides an epidemiological snapshot that reflects broader transitions occurring in tribal farming in central India.

High prevalence of agro-chemical induced vision conditions, cardiovascular disorders, and infectious diseases along with traditional health issues like sickle cell anaemia reflects the various health needs of rapidly transitioning communities in agricultural and socio-economic terms. The persistence of musculoskeletal disorders and respiratory conditions among workingage adults demonstrates the physical toll of intensive agricultural practices combined with occupational exposures. However, the trend is not gender biased as it is common complaint in both the sexes. These observations underscore the pressing need for holistic health interventions that cover both traditional health problems and emerging occupational health risks. The evidence demands convergent approaches combining occupational safety procedures, environmental health protection, genetic disease prevention and chronic disease control in culturally appropriate delivery systems. The morbidity profiles described in this research add to the emerging evidence base on tribal health in India, with implications for research and intervention programs aimed at reversing the unique health problems of indigenous farm communities against the backdrop of agricultural intensification and environmental change.

CHAPTER 6

MORTALITY SCENARIO IN FARMER HOUSEHOLDS

Mortality profile of tribal communities in India presents a web of complex epidemiological transitions, environmental exposures, and socio-economic determinants that distinguish these populations from mainstream society (Ministry of Health & Family Welfare and Ministry of Tribal Affairs, Government of India., 2018; Narain, 2023; Kunjumon et al., 2024). In previous chapter morbidity/disease pattern among the tribal farmers in Kelapur has provided some intropections for an in-depth analysis on attributes of mortality trends among tribal farmer and farm labourer communities of the Kelapur Taluka of Yavatmal Disstrict, Vidarbha region, Maharashtra, based on 1,061 households survey with a population of 4,601 persons. During field investigation, it was noted that most of the people hardly have very clear knowledge about aetiology of diseases and as so cause of the death, untill and unless there were some cases that required intermittent medical follow up or prescribed regular medications were administered to the patients and/or deceased persons and family members were equally concerned with the case. While research team was engaged in collecting household morbidity and mortality data, some of the informants reported the cause of deaths very precisely like cancer, malaria, diarrohea or else and others only could narrate some symptomatic descriptions of illness/diseases like ‘tumor’ “*pisah band ho gya tha, haath-pyr phul gyatha*” or “*burhapa*” etc. In such cases focused group interviews with villagers and ASHA workers helped in understanding of the illness/disease patterns in study areas. and altogether 285 deaths were reported in the past ten years with reference year 2015-2025.

Mortality Profile by Gender and Disease Categories

TABLE 6.1. Mortality Profile of Household Members (2015-2024)

Disease led to death	Female	Male	Total
Agro-Chemical Induced Conditions	0 (0.00%)	1 (0.35%)	1 (0.35%)
Musculoskeletal Disorders	1 (0.35%)	1 (0.35%)	2 (0.70%)
Neurological & Mental Health	1 (0.35%)	6 (2.11%)	7 (2.46%)
Cancers	6 (2.11%)	13 (4.56%)	19 (6.67%)
Cardiovascular & Circulatory Diseases	21 (7.37%)	19 (6.67%)	40 (14.04%)
Chronic Alcohol consumption	0 (0.00%)	1 (0.35%)	1 (0.35%)
Elderly natural death	47 (16.49%)	35 (12.28%)	82 (28.77%)
Endocrine and Metabolic Disorders	0 (0.00%)	3 (1.05%)	3 (1.05%)
Gastrointestinal and Liver Disorders	5 (1.8%)	4 (1.40%)	9 (3.20%)
Infectious and Parasitic Diseases	12 (4.21%)	9 (3.16%)	21 (7.37%)
Maternal & Perinatal and Gynaecological	4 (1.40%)	1 (0.35%)	5 (1.75%)
Musculoskeletal Disorders	0 (0.00%)	1 (0.35%)	1 (0.35%)
Neurological and Mental Health	1 (0.35%)	0 (0.00%)	1 (0.35%)
Renal and Urogenital	9 (3.16%)	7 (2.46%)	16 (5.61%)
Respiratory	11 (3.86%)	7 (2.46%)	18 (6.32%)
Sickle cell anaemia	3 (1.05%)	1 (0.35%)	4 (1.40%)
Unclassified or Unspecified	6 (2.11%)	4 (1.40%)	10 (3.51%)
Unnatural death	6 (2%)	29 (10%)	35 (12%)
Vector borne diseases	6 (2%)	4 (1.40%)	10 (3.51%)
Total	139 (49%)	146 (51%)	285 (100%)

Table 6.1 presents overall mortality data, revealing significant gender and disease-specific patterns in the 285 deaths (146 males, 139 females) observed within the study population. Elderly natural death (28.77%), cardiovascular and circulatory diseases (14.04%), and unnatural death (12.28%) were the top three contributing causes of death, reflecting a mortality pattern that suggests both natural aging processes and significant burdens from cardiovascular disease and external causes of death prevalent in this tribal population.

Elderly natural death was the leading cause of mortality at 28.77% (82 cases), with a higher burden among females (16.49%, 47 cases) compared to males (12.28%, 35 cases). This substantial proportion reflects the demographic characteristics of the study population and suggests longer life expectancy among females in this tribal community.

Cardiovascular and circulatory diseases accounted for 14.04% of mortality (40 cases), with a slightly higher burden among females (7.37%, 21 cases) compared to males (6.67%, 19 cases). This substantial burden represents the epidemiological transition occurring in tribal populations, where non-communicable diseases increasingly dominate over communicable diseases, aligning with observations from tribal regions of central India (Sathiyanarayanan et al., 2019).

Unnatural death was the third highest leading cause of death (12.28%, 35 cases), with a markedly higher mortality among males (10.18%, 29 cases) compared to females (2.11%, 6 cases). These deaths include occupational and road accidents (15), suicides (17) and Animal bites (3). This represents a substantial gender disparity in external causes of mortality, with males accounting for 82.9% of all unnatural deaths. This pattern of suicides is reflective of the wider agrarian crisis across the cotton cultivating districts of Vidarbha region, where farmer deaths have reached epidemic proportions, caused by crop failure, increasing costs of cultivation, and mounting debt burdens (Behere & Behere, 2008). A study revealed that debt, addiction, environmental problems, poor price realization for agricultural produce, and family responsibilities are major factors that are perceived as major contributing factors for farmer suicides in Vidarbha region (Dongre & Deshmukh, 2012). Another study reported that crop failure, indebtedness, economic crisis, unemployment, and lack of social support contribute significantly to mental distress among farmers in Yavatmal (Bomble & Lhungdim, 2020).

Though certain infectious conditions that comes under the category of affected organ, they were classified under infectious diseases such as TB except jaundice and hepatitis which were classified under gastrointestinal and liver disorders. Further. brain fever is classified under infectious diseases. Infectious and parasitic diseases contributed to 7.37% of mortality (21 cases), with a higher burden among females (4.21%, 12 cases) compared to males (3.16%, 9 cases). Tuberculosis, brain fever, COVID-19 and othe variants, leprosy, pneumonia with incomplete TB treatment and sepsis are categorised in this group. Although representing a smaller proportion, this still indicates a significant burden, when compared with national averages. Tuberculosis prevalence has been reported in tribal prevalence surveys to be 703 per 100,000 against the national prevalence of 256 per 100,000, with highly vulnerable tribes like Saharia in Madhya Pradesh reaching 1,518 per 100,000 (Rao et al., 2015; Narain, 2019).

Cancers showed a notable gender disparity, affecting 4.56% of males (13 cases) compared to 2.11% of females (6 cases), contributing to 6.67% of total mortality (19 cases). This represents more than double the cancer mortality rate among males compared to females.

Respiratory Diseases accounted for 6.32% of mortality (18 cases), with a higher burden among females (3.86%, 11 cases) compared to males (2.46%, 7 cases). Renal and urogenital diseases contributed to 5.61% of mortality (16 cases), with a sligtly higher burden among females (3.16%, 9 cases) compared to males (2.46%, 7 cases).

Vector-borne Diseases accounted for 3.51% of overall mortality (10 cases), with a higher burden among females (2.11%, 6 cases) compared to males (1.40%, 4 cases). The Vector-borne Disease category includes dengue, malaria, and chikungunya. This concurs with studies showing that tribal populations, though they account for approximately 8% of India's population, contribute 47% of all malaria cases, 70% of falciparum malaria, and 46% of deaths due to malaria (Dhariwal & Singh, 2015). The endemicity of vector-borne disease among Maharashtra tribal communities has been extensively reported, with about 50% of the overall malaria mortality in India being among the tribal population (Jain et al., 2015).

Age-Specific Mortality Patterns

Table 6.2: Mortality Profile of Deceased Members by Age Group

Disease led to death	Infant (<12 months)	Child (<59 months)	Young child (5-9 yrs)	Juvenile (>9 - <14 yrs)	Adult (15 – 64 yrs.)	Old (65 and more)	Total
Agro-Chemical Induced Conditions	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	1 (0.35%)	0 (0.00%)	1 (0.35%)
Musculoskeletal Disorders	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	1 (0.35%)	1 (0.35%)	2 (0.70%)
Neurological / Mental Health	0 (0.00%)	1 (0.35%)	0 (0.00 %)	0 (0.00 %)	6 (2.11%)	0 (0.00%)	7 (2.46%)
Cancers / Tumors	0 (0.00%)	0 (0.00%)	1 (0.35 %)	0 (0.00 %)	13 (4.56%)	5 (1.75%)	19 (6.67%)
Cardiovascular & Circulatory Diseases	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	25 (8.77%)	15 (5.26%)	40 (14.04%)
Chronic Alcohol consumption	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	1 (0.35%)	0 (0.00%)	1 (0.35%)
Elderly natural death	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	12 (4.21%)	70 (24.56%)	82 (28.77%)
Endocrine / Metabolic Disorders	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	2 (0.70%)	1 (0.35%)	3 (1.05%)
Gastrointestinal & Liver Disorders	0 (0.00%)	1 (0.35%)	0 (0.00 %)	0 (0.00 %)	4 (1.40%)	2 (0.70%)	7 (2.46%)
Hepatitic	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	2 (0.70%)	0 (0.00%)	2 (0.70%)
Infectious & Parasitic Diseases	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	14 (4.91%)	7 (2.46%)	21 (7.37%)
Maternal & Perinatal & Gynaecological	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	5 (1.75%)	0 (0.00%)	5 (1.75%)
Musculoskeletal Disorders	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	1 (0.35%)	0 (0.00%)	1 (0.35%)
Neurological / Mental Health	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	1 (0.35%)	0 (0.00%)	1 (0.35%)
Renal / Urogenital	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	13 (4.56%)	3 (1.05%)	16 (5.61%)
Respiratory	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	8 (2.81%)	10 (3.51%)	18 (6.32%)

Sickle cell anaemia	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	4 (1.40%)	0 (0.00%)	4 (1.40%)
Unclassified / Unspecified	0 (0.00%)	0 (0.00%)	0 (0.00 %)	0 (0.00 %)	5 (1.75%)	5 (1.75%)	10 (3.51%)
Unnatural death	1 (0.35%)	0 (0.00%)	0 (0.00 %)	2 (0.70 %)	26 (9.12%)	6 (2.11%)	35 (12.28%)
Vector-borne diseases	0 (0.00%)	1 (0.35%)	0 (0.00 %)	0 (0.00 %)	5 (1.75%)	4 (1.40%)	10 (3.51%)
Total	1 (0.35%)	4 (1.40%)	1 (0.35 %)	2 (0.70 %)	149 (52.28%)	129 (45.26%)	285 (100.00%)

The age-stratified mortality data in Table 6.2 reveals distinct patterns across different life stages, emphasizing the vulnerable phases and disease-specific risks faced by the tribal population. The data shows that mortality is heavily concentrated in two age groups: adults (15-64 years) accounting for 52.28% of all deaths (149 cases) and elderly villagers (65+ years) represent 45.26% (129 cases).

Infant and child mortality (under 5 years) was relatively low, with only 5 deaths total (1 infant under 12 months and 4 children 12-59 months), representing 1.75% of all mortality. The single infant death was attributed to unnatural causes. In the child group (12-59 months), deaths were attributed to neurological and mental health problems (1 case), gastrointestinal and liver disorders (1 case), and vector-borne diseases (1 case), with one case unspecified in the table data. Young child (5-9 years) and juvenile (>9-<14 years) groups showed minimal mortality, with only 1 death in the young child group (cancer/tumor) and 2 deaths in the juvenile group (both unnatural deaths). This low pediatric mortality suggests relatively effective maternal and child health interventions or improved living conditions compared to historical patterns. Child mortality (0-14 years) was relatively low in the study population (6 deaths, 2.1%), indicating partial success in child survival programs, though underreporting of early childhood mortality can not be ruled out. However, the observations establish the fact that there is an improvement and success in the targeted health programmes. The NFHS 5 data indicate that under five mortalities among Scheduled Tribes continues to be high when compared to the general population, with tribal populations having 50 deaths per 1,000 live births compared to the national average of 41.9 deaths per 1,000 live births and that tribal populations have 41.9 deaths per 1,000 live births (International Institute for Population Sciences [IIPS] & ICF, 2021; Kunjumon et al., 2024). Further, the persistence of these health and mortality disparities in scheduled tribe populations across India are confirmed by comparative analyses (Subrabanian & Joe, 2023). Gender trends revealed higher mortality among males in all age groups, consistent with national demographic trends but especially marked among the working-age groups (15-64 years), where lifestyle variables, work related risks and suicidal risk account for excess male deaths.

Adult mortality showed the highest diversity in causes of death and represented the largest burden at 52.28% of total deaths. The leading causes in this age group were unnatural death (causing road accidents, suicide, homicide, and animal attack) with 26 cases (9.12% of total mortality), representing the highest single cause of death in adults and highlighting significant external mortality risks. Cardiovascular and circulatory diseases contributed 25 cases (8.77%), indicating substantial burden of non-communicable diseases in the productive age group. Infectious and parasitic diseases accounted for 14 cases (4.91%), showing continued vulnerability to communicable diseases. Both cancers/tumors and renal/urogenital disorders each contributed 13 cases (4.56%), demonstrating significant disease burden during productive years. Other causes of natural deaths accounted for 12 cases (4.21%), suggesting premature aging or potential misclassification of deaths in this population. Other notable causes included respiratory diseases (8 cases, 2.81%), maternal and perinatal & gynaecological conditions (5 cases, 1.75%), vector-borne diseases (5 cases, 1.75%), and sickle cell anemia (4 cases, 1.40%).

Elderly mortality was dominated by natural aging processes, with elderly natural death accounting for 70 cases (24.56% of total mortality). However, several other conditions contributed significantly to elderly deaths including cardiovascular and circulatory diseases with 15 cases (5.26%), showing continued burden into advanced age. Respiratory diseases contributed 10 cases (3.51%), reflecting increased vulnerability of aging respiratory systems. Infectious and parasitic diseases accounted for 7 cases (2.46%), indicating continued susceptibility to communicable diseases. Unnatural death contributed 6 cases (2.11%), showing that external causes affect all age groups. Cancers/tumors accounted for 5 cases (1.75%), with lower burden than in adult years, while vector-borne diseases contributed 4 cases (1.40%), reflecting continued exposure risks throughout the lifespan.

Cancer distribution shows 19 total cases distributed as 13 in adults (4.56%), 5 in elderly (1.75%), and 1 in the young child group (0.35%). This adult predominance could indicate environmental or occupational exposures requiring further investigation. Vector-borne diseases showed minimal occurrence in pediatric groups (1 case in children 12-59 months), moderate burden in adults (5 cases, 1.75%), and continued presence in elderly (4 cases, 1.40%), suggesting lifelong exposure risks in this endemic region. Unnatural deaths totaling 35 cases were distributed as 1 infant (0.35%), 2 juveniles (0.70%), 26 adults (9.12%), and 6 elderly (2.11%). The overwhelming concentration in the adult age group (74.3% of all unnatural deaths) highlights the critical risk period for external causes of death, consistent with agricultural crisis patterns documented in the Vidarbha region.

Prevalence of both communicable and non-communicable diseases across age groups indicates an incomplete epidemiological transition in this tribal population. Substantial burden of cardiovascular diseases (40 cases total) and cancers (19 cases total) coexists with continued risks from infectious diseases (21 cases) and vector-borne diseases (10 cases). This dual disease burden pattern is consistent with findings from other tribal areas in central India, where traditional infectious disease risks persist alongside emerging non-communicable disease challenges (Jain et al., 2015). The concentration of mortality in adult and elderly age groups (97.54% combined) with relatively low pediatric mortality suggests improvements in early life survival while highlighting the growing burden of adult and elderly health challenges in this tribal community.

TABLE 6.3. Mortality Profile of Deceased Farmers:

Disease led to death	Farmers			Agriculture Labours			Total		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
Agro-Chemical Induced Conditions	0 (0.00%)	1 (0.67%)	1 (0.67%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.43%)	1 (0.43%)
Musculoskeletal Disorders	0 (0.00%)	1 (0.67%)	1 (0.67%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.43%)	1 (0.43%)
Neurological / Mental Health	0 (0.00%)	2 (1.33%)	2 (1.33%)	1 (1.20%)	0 (0.00%)	1 (1.20%)	1 (0.43%)	2 (0.86%)	3 (1.29%)
Cancers / Tumors	3 (2.00%)	8 (5.33%)	11 (7.33%)	1 (1.20%)	4 (4.82%)	5 (6.02%)	4 (1.72%)	12 (5.15%)	16 (6.87%)
Cardiovascular & Circulatory Diseases	12 (8.00%)	8 (5.33%)	20 (13.33%)	5 (6.02%)	6 (7.23%)	11 (13.25%)	17 (7.30%)	14 (6.01%)	31 (13.30%)
Chronic Alcohol consumption	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (1.20%)	1 (1.20%)	0 (0.00%)	1 (0.43%)	1 (0.43%)
Elderly natural death	31 (20.67%)	21 (14.00%)	52 (34.67%)	7 (8.43%)	11 (13.25%)	18 (21.69%)	38 (16.31%)	32 (13.73%)	70 (30.04%)
Endocrine and Metabolic Disorders	0 (0.00%)	2 (1.33%)	2 (1.33%)	0 (0.00%)	1 (1.20%)	1 (1.20%)	0 (0.00%)	3 (1.29%)	3 (1.29%)
Gastrointestinal and Liver Disorders	1 (0.67%)	1 (0.67%)	2 (1.33%)	1 (1.20%)	0 (0.00%)	1 (1.20%)	2 (0.86%)	1 (0.43%)	3 (1.29%)
Hepatitic	1 (0.67%)	0 (0.00%)	1 (0.67%)	1 (1.20%)	0 (0.00%)	1 (1.20%)	2 (0.86%)	0 (0.00%)	2 (0.86%)
Infectious and Parasitic Diseases	5 (3.33%)	6 (4.00%)	11 (7.33%)	4 (4.82%)	3 (3.61%)	7 (8.43%)	9 (3.86%)	9 (3.86%)	18 (7.73%)
Maternal & Perinatal and Gynaecological	4 (2.67%)	0 (0.00%)	4 (2.67%)	0 (0.00%)	1 (1.20%)	1 (1.20%)	4 (1.72%)	1 (0.43%)	5 (2.15%)
Musculoskeletal Disorders	0 (0.00%)	1 (0.67%)	1 (0.67%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.43%)	1 (0.43%)
Renal and Urogenital	3 (2.00%)	2 (1.33%)	5 (3.33%)	6 (7.23%)	5 (6.02%)	11 (13.25%)	9 (3.86%)	7 (3.00%)	16 (6.87%)
Respiratory	3 (2.00%)	4 (2.67%)	7 (4.67%)	7 (8.43%)	2 (2.41%)	9 (10.84%)	10 (4.29%)	6 (2.58%)	16 (6.87%)
Sickle cell anemia	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (3.61%)	1 (1.20%)	4 (4.82%)	3 (1.29%)	1 (0.43%)	4 (1.72%)
Unclassified and Unspecified	4 (2.67%)	3 (2.00%)	7 (4.67%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	4 (1.72%)	3 (1.29%)	7 (3.00%)
Unnatural death	3 (2.00%)	15 (10.00%)	18 (12.00%)	0 (0.00%)	8 (9.64%)	8 (9.64%)	3 (1.29%)	23 (9.87%)	26 (11.16%)
Vector-borne diseases	3 (2.00%)	2 (1.33%)	5 (3.33%)	2 (2.41%)	2 (2.41%)	4 (4.82%)	5 (2.15%)	4 (1.72%)	9 (3.86%)
Total	38 (45.78%)	45 (54.22%)	83 (100.00%)	73 (48.67%)	77 (51.33%)	150 (100.00%)	111 (47.64%)	122 (52.36%)	233 (100.00%)

Table 6.3 presents the mortality profile of 187 farmers who died in the Kelapur Taluka of Yavatmal District, Maharashtra, categorised by diagnosed diseases causing death and disaggregated by sex. The data indicates notable patterns in cause of death among tribal farming communities, with 52.90% (99 deaths) of total mortality reported by males and 47.10% (88 deaths) reported by females. The highest category of death is elderly natural death,

accounting for 57 deaths (30.50% of total deaths), representing the single largest cause of mortality among farmers in this tribal community. This trend indicates that even with agricultural intensification, natural aging remains the major cause of death among this tribal farming population.

Cardiovascular and circulatory diseases constitute a significant mortality burden, accounting for 15.00% of all deaths (28 cases) with equal distribution between males and females (14 cases each). This relatively equal gender distribution in cardiovascular mortality contrasts with general urban trends where males have greater prevalence, implying specialized environmental or occupational risk factors in agricultural areas. The substantial burden of cardiovascular disease reflects the epidemiological transition occurring in rural tribal populations.

Unnatural deaths (accidents, suicide, homicide and animal attack) emerges as a critical concern, representing 10.70% of all fatalities (20 cases) with a dramatic gender imbalance of 18 men (9.60%) compared to just 2 women (1.10%). This pattern concurs with the wider agrarian crisis literature on farmer suicides, specifically among male farmers under economic stress due to agricultural intensification and debt burdens prevalent in the Vidarbha region.

Respiratory disease affected 7.00% of the population (13 cases), with females showing higher mortality (8 cases, 4.30%) compared to males (5 cases, 2.70%). This differential may result from differential exposure patterns where women experience greater exposure to indoor air pollution from cooking practices or specific farming activities involving dust and agricultural residues.

Vector-borne diseases and infectious & parasitic diseases each account for 6.40% of overall mortality (12 cases each), representing significant public health challenges in this tribal agricultural population. The high proportion results from the convergence of environmental degradation, climate change, and farming practices that create favorable conditions for disease vectors while disrupting natural ecological balances.

Cancer-related mortality contributes 4.80% of deaths (9 cases), with a notable gender disparity showing 7 male deaths (3.70%) compared to 2 female deaths (1.10%). The occurrence of various cancer types indicates probable exposure to carcinogenic substances via agricultural chemicals, though definitive causality requires further investigation.

Renal and urogenital problems cause 5.30% of mortality (10 cases), possibly due to exposure to agricultural pesticides, contaminated drinking water sources, or chronic dehydration from agricultural labor under extreme climatic conditions. This burden is particularly concerning given the known nephrotoxic effects of certain pesticides commonly used in cotton cultivation.

Several other conditions contribute to the mortality profile, including gastrointestinal and liver disorders (2.70%), blood and genetic disorders (1.60%), maternal and perinatal problems (1.60%), and neurological/mental health issues (1.60%). Unclassified deaths account for 4.30% of cases, indicating potential gaps in diagnostic capabilities or death certification processes.

Vidarbha tribal farmers' mortality profile exhibits both convergences and divergences from wider Indian health trends. While cardiovascular diseases represent a major cause of death consistent with national patterns, the prevalence of vector-borne diseases (6.40%) and unnatural deaths (10.70%) are substantially higher than national averages, reflecting regional environmental factors and inadequate public health infrastructure in tribal communities.

10.70% unnatural death rate is particularly concerning when viewed against Maharashtra's status as a leading state for farmer suicides. According to studies, debt pressures, crop loss, and social exclusion factors, possibly worsened by agricultural intensification, contribute to this alarming trend (Behere & Behere, 2008). The pattern of observed mortality indicates several ways in which intensification of agriculture affects health outcomes. The occurrence of cancers, renal disease, and respiratory diseases aligns with reported health effects of pesticide exposure, as documented in studies by Mesnage and Antoniou (2018) and Curl *et al.* (2020) in comparable agricultural settings.

High burden of vector-borne diseases may reflect ecological disturbances linked to intensive agriculture, where monoculture production, augmented irrigation, and pesticide resistance create favorable environments for disease vectors while disrupting natural predator-prey dynamics that once regulated vector populations (Rivero et al., 2010). This complex interplay between agricultural practices and health outcomes underscores the need for comprehensive approaches to address both agricultural sustainability and farmer health in tribal communities.

Table 6.4. Cause Specific Mortality Profile of Studied Population (2020-2024)

Year	Disease led to death	Female	Male	Total
2024	Cancers / Tumors	0 (0.00%)	1 (3.23%)	1 (3.23%)
	Cardiovascular & Circulatory Diseases	2 (6.45%)	3 (9.68%)	5 (16.13%)
	Elderly natural death	8 (25.81%)	1 (3.23%)	9 (29.03%)
	Gastrointestinal & Liver Disorders	1 (3.23%)	2 (6.45%)	1 (3.23%)
	Hepatitic	1 (3.23%)	0 (0.00%)	1 (3.23%)
	Infectious & Parasitic Diseases	1 (3.23%)	0 (0.00%)	1 (3.23%)
	Neurological / Mental Health	1 (3.23%)	1 (3.23%)	2 (6.45%)
	Renal / Urogenital	2 (6.45%)	2 (6.45%)	4 (12.90%)
	Respiratory	1 (3.23%)	0 (0.00%)	1 (3.23%)
	Unnatural death	1 (3.23%)	4 (12.90%)	5 (16.13%)
	Vector-borne diseases	1 (3.23%)	0 (0.00%)	1 (3.23%)
	Total	19 (61.29%)	12 (38.71%)	31 (100.00%)
2023	Elderly natural death	5 (19.23%)	3 (11.54%)	8 (30.77%)
	Endocrine / Metabolic Disorders	0 (0.00%)	1 (3.85%)	1 (3.85%)
	Gastrointestinal & Liver Disorders	0 (0.00%)	1 (3.85%)	1 (3.85%)
	Infectious & Parasitic Diseases	1 (3.85%)	1 (3.85%)	2 (7.69%)
	Neurological / Mental Health	0 (0.00%)	1 (3.85%	1 (3.85%)
	Renal / Urogenital	2 (7.69%)	0 (0.00%)	2 (7.69%)
	Respiratory	3 (11.54%)	1 (3.85%)	4 (15.38%)
	Sickle cell anaemia	1 (3.85%)	1 (3.85%)	2 (7.69%)
	Unnatural death	0 (0.00%)	3 (11.54%)	3 (11.54%)
	Vector-borne diseases	1 (3.85%)	1 (3.85%)	2 (7.69%)
	Total	13 (50.00%)	13 (50.00%)	26 (100.00%)
2022	Cancers / Tumors	2 (7.69%)	1 (3.85%)	3 (11.54%)
	Cardiovascular & Circulatory Diseases	2 (7.69%)	4 (15.38%)	6 (23.08%)
	Elderly natural death	5 (19.23%)	3 (11.54%)	8 (30.77%)
	Endocrine / Metabolic Disorders	0 (0.00%)	1 (3.85%)	1 (3.85%)
	Hepatitic	1 (3.85%)	0 (0.00%)	1 (3.85%)
	Infectious & Parasitic Diseases	1 (3.85%)	0 (0.00%)	1 (3.85%)
	Unclassified / Unspecified	1 (3.85%)	1 (3.85%)	2 (7.69%)
	Unnatural death	2 (7.69%)	2 (7.69%)	4 (15.38%)
	Total	14 (53.85%)	12 (46.15%)	26 (100.00%)
2021	Cancers / Tumors	0 (0.00%)	2 (5.88%)	2 (5.88%)
	Cardiovascular & Circulatory Diseases	4 (11.76%)	1 (2.94%)	5 (14.71%)
	Elderly natural death	4 (11.76%)	3 (8.82%)	7 (20.59%)
	Gastrointestinal & Liver Disorders	1 (2.94%)	0 (0.00%)	1 (2.94%)
	Infectious & Parasitic Diseases	3 (8.82%)	3 (8.82%)	6 (17.65%)
	Maternal & Perinatal & Gynaecological	1 (2.94%)	0 (0.00%)	1 (2.94%)
	Renal / Urogenital	2 (5.88%)	1 (2.94%)	3 (8.82%)
	Respiratory	3 (8.82%)	0 (0.00%)	3 (8.82%)
	Sickle cell anaemia	2 (5.88%)	0 (0.00%)	2 (5.88%)
	Unnatural death	0 (0.00%)	3 (8.82%)	3 (8.82%)

	Vector-borne diseases	0 (0.00%)	1 (2.94%)	1 (2.94%)
	Total	20 (58.82%)	14 (41.18%)	34 (100.00%)
2020	Neurological / Mental Health	0 (0.0)	1 (0.0)	1 (0.0)
	Cancers / Tumors	0 (0.0)	3 (0.1)	3 (0.1)
	Cardiovascular & Circulatory Diseases	1 (0.0)	0 (0.0)	1 (0.0)
	Elderly natural death	3 (0.1)	6 (0.3)	9 (0.4)
	Renal / Urogenital	0 (0.0)	2 (0.1)	2 (0.1)
	Respiratory	0 (0.0)	1 (0.0)	1 (0.0)
	Unclassified / Unspecified	1 (0.0)	1 (0.0)	2 (0.1)
	Unnatural death	0 (0.0)	4 (0.2)	4 (0.2)
	Vector-borne diseases	0 (0.0)	1 (0.0)	1 (0.0)
	Total	5 (0.2)	19 (0.8)	24 (1.0)
ALL YEAR DATA	Cancers / Tumors	2 (1.69%)	4 (3.39%)	6 (5.08%)
	Cardiovascular & Circulatory Diseases	8 (6.78%)	8 (6.78%)	16 (13.56%)
	Elderly natural death	22 (18.64%)	10 (8.47%)	32 (27.12%)
	Endocrine / Metabolic Disorders	0 (0.00%)	2 (1.69%)	2 (1.69%)
	Gastrointestinal & Liver Disorders	2 (1.69%)	2 (1.69%)	4 (3.39%)
	Hepatitic	2 (1.69%)	0 (0.00%)	2 (1.69%)
	Infectious & Parasitic Diseases	6 (5.08%)	4 (3.39%)	10 (8.47%)
	Maternal & Perinatal & Gynaecological Problem	1 (0.85%)	0 (0.00%)	1 (0.85%)
	Neurological / Mental Health	1 (0.85%)	2 (1.69%)	3 (2.54%)
	Renal / Urogenital	6 (5.08%)	3 (2.54%)	9 (7.63%)
	Respiratory Problem	7 (5.93%)	1 (0.85%)	8 (6.78%)
	Sickle cell anemia	3 (2.54%)	1 (0.85%)	4 (3.39%)
	Unclassified / Unspecified	1 (0.85%)	1 (0.85%)	2 (1.69%)
	Unnatural death	3 (2.54%)	12 (10.17%)	15 (12.71%)
	Vector-borne diseases	2 (1.69%)	2 (1.69%)	4 (3.39%)
	Total	66 (55.93%)	52 (44.07%)	118 (100.00%)

Table 6.4 presents a comprehensive temporal analysis of 141 household deaths spanning of five years i.e. from 2020 to 2024 in the study area, with 66 male deaths (46.81%) and 75 female deaths (53.19%). The data reveals distinct temporal patterns across different disease categories and demonstrates evolving mortality trends in this tribal population over the five-year study period.

Elderly natural death emerges as the leading cause of mortality across all years, accounting for 41 deaths (29.08% of total mortality) with a notable female predominance (25 cases, 17.73%) compared to males (16 cases, 11.35%). The temporal distribution shows 9 deaths in 2024 (29.03% of that year's deaths), 8 deaths each in 2023 (30.77%) and 2022 (30.77%), 7 deaths in 2021 (20.59%), and 9 deaths in 2020 (37.50% of that year's deaths). The sustained prominence of elderly natural death reflects the aging demographic structure of this tribal population.

Cardiovascular and circulatory diseases constitute the second major mortality burden, accounting for 17 deaths (12.06% of total mortality) with a slight female predominance (9 females vs 8 males). The temporal pattern shows notable fluctuations: 6 deaths in 2022 (23.08% of that year's deaths), 5 deaths each in 2024 (16.13%) and 2021 (14.71%), 1 death in 2020 (4.17%), and no deaths recorded in 2023. This varying pattern may reflect seasonal factors, diagnostic capabilities, or genuine temporal variations in cardiovascular risk factors.

Unnatural death represents a critical public health concern, accounting for 15 deaths (10.64% of total mortality) with a stark gender disparity showing 12 male deaths (8.51%) compared to only 3 female deaths (2.13%). The temporal distribution reveals 5 deaths in 2024 (16.13% of that year's deaths), 4 deaths each in 2022 (15.38%) and 2020 (16.67%), 3 deaths each in 2023 (11.54%) and 2021 (8.82%). This persistent burden across all years, with overwhelming male predominance (80% of unnatural deaths), reflects the ongoing agrarian crisis and mental health challenges facing male farmers in the region.

Infectious and parasitic diseases contributed 10 deaths (7.09% of total) with female predominance (6 cases vs 4 males). The temporal distribution shows a declining trend from 6 deaths in 2021 (17.65% of that year's deaths) to 2 deaths in 2023 (7.69%), 1 death each in 2024 (3.23%) and 2022 (3.85%), with no deaths recorded in 2020. This declining trend may indicate improved healthcare access or successful public health interventions.

Cancer-related mortality shows 9 deaths (6.38% of total) with male predominance (7 cases vs 2 females). The temporal distribution reveals 3 deaths each in 2020 (12.50% of that year's deaths) and 2022 (11.54%), 2 deaths in 2021 (5.88%), 1 death in 2024 (3.23%), and no deaths recorded in 2023. The consistent presence across multiple years, with male predominance, may reflect occupational exposures to agricultural chemicals or lifestyle factors.

Renal and urogenital problems account for 9 deaths (6.38% of total) with female predominance (6 cases vs 3 males). The temporal clustering shows 4 deaths in 2024 (12.90% of that year's deaths), 3 deaths in 2021 (8.82%), 2 deaths each in 2020 (8.33%) and 2023

(7.69%), with no deaths recorded in 2022. This pattern may reflect cumulative effects of agricultural chemical exposure or varying environmental stressors affecting kidney health.

Respiratory diseases contributed 9 deaths (6.38% of total) with strong female predominance (8 cases vs 1 male). The temporal distribution shows 4 deaths in 2023 (15.38% of that year's deaths), 3 deaths in 2021 (8.82%), 1 death each in 2024 (3.23%) and 2020 (4.17%), with no deaths recorded in 2022. The female predominance may reflect differential exposure patterns, including indoor air pollution from cooking practices.

Vector-borne diseases account for 8 deaths (5.67% of total) with slight male predominance (5 cases vs 3 females). The temporal distribution shows 2 deaths in 2023 (7.69% of that year's deaths), 1 death each in 2024 (3.23%), 2021 (2.94%), and 2020 (4.17%), with no deaths recorded in 2022. The persistent presence across multiple years indicates sustained endemicity of vector-borne diseases in the region.

Gastrointestinal and liver disorders account for 4 deaths (2.84% of total) with equal gender distribution (2 females, 2 males). Sickle cell anemia contributed 4 deaths (2.84%) with female predominance (3 cases vs 1 male), showing 2 deaths each in 2023 (7.69% of that year's deaths) and 2021 (5.88%). Neurological and mental health issues contributed 4 deaths (2.84%), distributed as 2 deaths in 2024 (6.45%), 1 death each in 2023 (3.85%) and 2020 (4.17%).

Endocrine and metabolic disorders contributed 2 deaths (1.42%), both occurring in males during 2023 and 2022. Hepatitic conditions accounted for 2 deaths (1.42%), both in females during 2024 and 2022. Unclassified deaths contributed 4 deaths (2.84%), with 2 deaths each in 2022 (7.69%) and 2020 (8.33%). Maternal and perinatal conditions contributed 1 death (0.71%) in 2021.

Temporal trends reveal several important patterns. The persistence of unnatural deaths across all time periods reflects the ongoing agrarian crisis in the Vidarbha region, where cotton farming difficulties and debt burdens continue to affect farmer mental health. Literature has shown that 95% of cotton growers in Vidarbha face enormous debt burdens (Kennedy & King, 2014), while studies from Yavatmal District reveal that 58% of farmers suffer from mental health stress, with anxiety and insomnia being the most prevalent symptoms (55%) (Bomble & Lhungdim, 2020).

Fluctuating patterns in cardiovascular diseases, with complete absence in 2023, suggest complex interactions between environmental factors, healthcare access, and disease surveillance capabilities. The declining trend in infectious diseases from 2021 onwards may indicate improved healthcare interventions or changes in disease exposure patterns. The consistent burden of elderly natural deaths across all years reflects demographic transitions, while the persistent cancer burden, particularly among males, warrants investigation into occupational and environmental risk factors associated with intensive agricultural practices in tribal communities. The sustained presence of vector-borne diseases across multiple years is consistent with studies demonstrating that tribal regions maintain malaria as a leading cause of morbidity and mortality (Chourasia et al., 2017). The clustering of renal disease deaths in recent years (2024 showing the highest burden) may reflect cumulative effects of long-term exposure to agricultural chemicals or environmental pollutants, highlighting the need for targeted interventions addressing occupational health risks in farming communities.

Table 6.5: Gender-Wise Distribution of Cause Specific mortality Profile of Studied Population During Pre and Post-Covid-19 Scenario (10-Year Mortality)

Disease led to death	Covid-19 (2020-2021)			Post Covid (2022-2023)			Pre-Covid (2015-2019)			Total		
	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
Agro-Chemical Induced Conditions	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.70%)	1 (0.70%)	0 (0.00%)	1 (0.35%)	1 (0.35%)
Musculoskeletal Disorders	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.70%)	1 (0.70%)	2 (1.40%)	1 (0.35%)	1 (0.35%)	2 (0.70%)
Neurological / Mental Health	0 (0.00%)	1 (1.72%)	1 (1.72%)	1 (1.19%)	2 (2.38%)	3 (3.57%)	0 (0.00%)	3 (2.10%)	3 (2.10%)	1 (0.35%)	6 (2.11%)	7 (2.46%)
Cancers / Tumors	0 (0.00%)	5 (8.62%)	5 (8.62%)	2 (2.38%)	2 (2.38%)	4 (4.76%)	4 (2.80%)	6 (4.20%)	10 (6.99%)	6 (2.11%)	13 (4.56%)	19 (6.67%)
Cardiovascular & Circulatory Diseases	5 (8.62%)	1 (1.72%)	6 (10.34%)	4 (4.76%)	7 (8.33%)	11 (13.10%)	12 (8.39%)	11 (7.69%)	23 (16.08%)	21 (7.37%)	19 (6.67%)	40 (14.04%)
Chronic Alcohol consumption	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.70%)	1 (0.70%)	0 (0.00%)	1 (0.35%)	1 (0.35%)
Elderly natural death	7 (12.07%)	9 (15.52%)	16 (27.59%)	18 (21.43%)	7 (8.33%)	25 (29.76%)	22 (15.38%)	19 (13.29%)	41 (28.67%)	47 (16.49%)	35 (12.28%)	82 (28.77%)
Endocrine / Metabolic Disorders	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (2.38%)	2 (2.38%)	0 (0.00%)	1 (0.70%)	1 (0.70%)	0 (0.00%)	3 (1.05%)	3 (1.05%)
Gastrointestinal & Liver Disorders	1 (1.72%)	0 (0.00%)	1 (1.72%)	1 (1.19%)	2 (2.38%)	3 (3.57%)	1 (0.70%)	2 (1.40%)	3 (2.10%)	3 (1.05%)	4 (1.40%)	7 (2.46%)
Hepatitic	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (2.38%)	0 (0.00%)	2 (2.38%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (0.70%)	0 (0.00%)	2 (0.70%)
Infectious & Parasitic Diseases	3 (5.17%)	3 (5.17%)	6 (10.34%)	3 (3.57%)	1 (1.19%)	4 (4.76%)	6 (4.20%)	5 (3.50%)	11 (7.69%)	12 (4.21%)	9 (3.16%)	21 (7.37%)
Maternal & Perinatal & Gynaecological	1 (1.72%)	0 (0.00%)	1 (1.72%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (2.10%)	1 (0.70%)	4 (2.80%)	4 (1.40%)	1 (0.35%)	5 (1.75%)
Musculoskeletal Disorders	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.70%)	1 (0.70%)	0 (0.00%)	1 (0.35%)	1 (0.35%)
Neurological / Mental Health	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.70%)	0 (0.00%)	1 (0.70%)	1 (0.35%)	0 (0.00%)	1 (0.35%)
Renal / Urogenital	2 (3.45%)	3 (5.17%)	5 (8.62%)	4 (4.76%)	2 (2.38%)	6 (7.14%)	3 (2.10%)	2 (1.40%)	5 (3.50%)	9 (3.16%)	7 (2.46%)	16 (5.61%)

Respiratory	3 (5.17%)	1 (1.72%)	4 (6.90%)	4 (4.76%)	1 (1.19%)	5 (5.95%)	4 (2.80%)	5 (3.50%)	9 (6.29%)	11 (3.86%)	7 (2.46%)	18 (6.32%)
Sickle cell anemia	2 (3.45%)	0 (0.00%)	2 (3.45%)	1 (1.19%)	1 (1.19%)	2 (2.38%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (1.05%)	1 (0.35%)	4 (1.40%)
Unclassified / Unspecified	1 (1.72%)	1 (1.72%)	2 (3.45%)	1 (1.19%)	1 (1.19%)	2 (2.38%)	4 (2.80%)	2 (1.40%)	6 (4.20%)	6 (2.11%)	4 (1.40%)	10 (3.51%)
Unnatural death	0 (0.00%)	7 (12.07%)	7 (12.07%)	3 (3.57%)	9 (10.71%)	12 (14.29%)	3 (2.10%)	13 (9.09%)	16 (11.19%)	6 (2.11%)	29 (10.18%)	35 (12.28%)
Vector-borne diseases	0 (0.00%)	2 (3.45%)	2 (3.45%)	2 (2.38%)	1 (1.19%)	3 (3.57%)	4 (2.80%)	1 (0.70%)	5 (3.50%)	6 (2.11%)	4 (1.40%)	10 (3.51%)
Total	25 (43.10%)	33 (56.90%)	58 (100.00%)	46 (54.76%)	38 (45.24%)	84 (100.00%)	68 (47.55%)	75 (52.45%)	143 (100.00%)	139 (48.77%)	146 (51.23%)	285 (100.00%)

Table 6.5 presents a comprehensive analysis of cause-specific mortality patterns across COVID-19 (2020-2021), post-Covid (2022-2023), and Pre-Covid (2015-2019) periods among 285 deaths in the studied tribal villages, with 139 female deaths (48.77%) and 146 male deaths (51.23%) altogether. Temporal analysis reveals significant shifts in disease patterns and mortality trends associated with the COVID-19 pandemic and its aftermath.

The COVID-19 period recorded 58 deaths (20.35% of total mortality) with notable gender distribution showing 25 female deaths (43.10%) and 33 male deaths (56.90%) during this acute phase. Elderly natural death emerged as the leading cause with 16 deaths (27.59% of COVID period deaths), followed by unnatural death and cardiovascular diseases each with significant burdens. The predominance of elderly deaths during this period reflects the known age-related vulnerability to COVID-19, while cardiovascular complications align with documented COVID-19 comorbidities. Indigenous populations showed particular vulnerability to COVID-19 as they had minimal contact with outside pathogens, making them more susceptible to novel infections (Kshatriya & Acharya, 2016).

The post-Covid period showed 84 deaths (29.47% of total mortality) with a shift in gender distribution to 46 female deaths (54.76%) and 38 male deaths (45.24%). Elderly natural death remained dominant with 25 deaths (29.76% of post-Covid deaths), followed by unnatural death with 12 deaths (14.29%) and cardiovascular diseases with 11 deaths (13.10%). The persistent burden of cardiovascular diseases in this period may reflect delayed healthcare access and chronic disease management disruptions caused by the pandemic. Maharashtra experienced significant impact on life expectancy during COVID-19, with age-specific case fatality rates increasing with age, reaching 7% by age 60 and 11% in those aged 80 and above (Vasishtha et al., 2021).

Pre-Covid period had recorded 143 deaths (50.18% of total mortality), showing 68 female deaths (47.55%) and 75 male deaths (52.45%). Elderly natural death dominated with 41 deaths (28.67% of Pre-Covid deaths), followed by cardiovascular diseases with 23 deaths (16.08%) and unnatural death with 16 deaths (11.19%). This baseline pattern reflects the ongoing epidemiological transition in tribal populations, where tribal communities are experiencing rapid increases in non-communicable diseases such as hypertension, diabetes, and cardiovascular diseases alongside traditional disease burdens (Narain, 2022).

Temporal Pattern Analysis

The data reveals several critical temporal patterns across the three periods. Cardiovascular mortality showed variation across periods with 23 deaths in Pre-Covid (16.08% of that period), 6 deaths in COVID (10.34%), and 11 deaths in post-Covid (13.10%), reflecting both direct COVID-19 effects and healthcare disruption impacts. Rural India has experienced an epidemiological transition with NCD burden increasing from 35.9% to 54.9% while communicable disease burden declined from 47.7% to 22.1% during recent decades (Yadav and Arokiasamy, 2014).

Cancer mortality demonstrated notable temporal clustering with 10 deaths in Pre-Covid (6.99% of that period), 5 deaths in COVID (8.62%), and 4 deaths in post-Covid (4.76%), showing potential diagnostic delays during the pandemic. The COVID period showed an unusually high proportion of cancer deaths, possibly reflecting delayed diagnosis leading to more severe presentations.

Unnatural death patterns revealed persistent mental health challenges across all periods, with clear male predominance evident in Pre-Covid (13 males vs 3 females) and post-Covid (9 males vs 3 females) periods, while COVID period showed 7 males with no female unnatural deaths. The consistent burden of unnatural deaths reflects ongoing agrarian distress in the Vidarbha region, where farming communities face chronic economic pressures and mental health challenges (Bomble & Lhungdim, 2020).

Infectious and parasitic diseases showed interesting temporal variations with 11 deaths in pre-Covid (7.69% of that period), 6 deaths in COVID (10.34%), and 4 deaths in post-Covid (4.76%), potentially indicating improved infection control measures or reduced healthcare seeking during pandemic restrictions. Vector-borne diseases-maintained presence across periods with 5 deaths in pre-Covid (3.50%), 2 deaths in COVID (3.45%), and 3 deaths in post-Covid (3.57%), demonstrating persistent endemicity in the region despite public health interventions (Chourasia et al., 2017).

Renal and urogenital problems showed stability across periods with 5 deaths in Pre-Covid (3.50%), 5 deaths in COVID (8.62%), and 6 deaths in post-Covid (7.14%), possibly reflecting chronic environmental exposures from agricultural chemicals. The COVID period showed a proportionally higher burden of renal disease, which may be related to COVID-19's known effects on kidney function.

Respiratory diseases demonstrated variation with 9 deaths in Pre-Covid (6.29%), 4 deaths in COVID (6.90%), and 5 deaths in post-Covid (5.95%). Despite COVID-19 being a respiratory illness, the proportion remained relatively stable, possibly indicating that other respiratory conditions continued to affect this population.

Gender-Specific Patterns

The COVID period showed a notable shift toward male mortality (56.90% vs 43.10% female), contrasting with the more balanced distributions in other periods. This pattern aligns with global observations of higher COVID-19 mortality among males. The post-Covid period reversed this trend with female predominance (54.76% vs 45.24% male), possibly reflecting delayed healthcare effects or other indirect pandemic impacts on women.

Public Health Implications

The mortality patterns reveal the complex interplay between pandemic effects and underlying health system challenges in tribal communities. Life expectancy in India declined by approximately 2.0 years in 2020 compared to 2019, with negative impacts more pronounced among men (Yadav et al., 2021). The data suggests that while direct COVID-19 mortality was significant in this rural tribal population, indirect effects through healthcare disruption and socioeconomic impacts were substantial (Mittal et al., 2023).

The persistent dominance of elderly natural death across all periods (41 Pre-Covid, 16 COVID, 25 Post-Covid) reflects both demographic transitions and potential gaps in chronic disease management. Tribal populations face a triple burden of undernutrition, obesity, and cardiovascular disease risks due to socio-cultural transitions and epidemiological changes (Kshatriya & Acharya, 2016). The temporal analysis underscores the need for strengthened health systems capable of managing both communicable and non-communicable disease burdens while maintaining essential services during health emergencies, with targeted interventions addressing mental health support for farmers, cardiovascular disease prevention and management, and continued vector control programs in tribal communities.

Mortality Among Household Members by Kinship Role

Table 6.6: Distribution of Deceased Household Members by Cause of Death and Kinship Role

Disease led to death	Brother	Daughter	Daughter-in-law	Father	Father in law	Grand Father	Grand Mother	Grandson	Husband	Mother	Mother-in-Law	Niece	Son	Wife	Total
Agro-Chemical Induced Conditions	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)
Musculoskeletal Disorders	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	2 (0.70%)
Neurological / Mental Health	0 (0.00%)	1 (0.35%)	0 (0.00%)	3 (1.05%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (1.05%)	0 (0.00%)	7 (2.46%)
Cancers / Tumors	0 (0.00%)	1 (0.35%)	0 (0.00%)	7 (2.46%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	4 (1.40%)	2 (0.70%)	1 (0.35%)	0 (0.00%)	1 (0.35%)	2 (0.70%)	19 (6.67%)
Cardiovascular & Circulatory Diseases	1 (0.35%)	0 (0.00%)	0 (0.00%)	9 (3.16%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	6 (2.11%)	13 (4.56%)	1 (0.35%)	0 (0.00%)	3 (1.05%)	6 (2.10%)	40 (14.04%)
Chronic Alcohol consumption	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)
Elderly natural death	0 (0.00%)	0 (0.00%)	0 (0.00%)	35 (12.28%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	44 (15.44%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (1.05%)	82 (28.77%)
Endocrine / Metabolic Disorders	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (1.05%)
Gastrointestinal & Liver Disorders	1 (0.35%)	1 (0.35%)	0 (0.00%)	2 (0.70%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	2 (0.70%)	7 (2.46%)

Hepatitic	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (0.70%)
Infectious & Parasitic Diseases	0 (0.00%)	1 (0.35%)	2 (0.70%)	5 (1.75%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	8 (2.81%)	0 (0.00%)	0 (0.00%)	3 (1.05%)	1 (0.35%)	21 (7.37%)
Maternal & Perinatal & Gynaecological	0 (0.00%)	1 (0.35%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (0.70%)	5 (1.75%)
Musculoskeletal Disorders	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)
Neurological / Mental Health	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)
Renal / Urogenital	0 (0.00%)	0 (0.00%)	1 (0.35%)	3 (1.05%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (1.05%)	4 (1.40%)	0 (0.00%)	0 (0.00%)	2 (0.70%)	3 (1.05%)	16 (5.61%)
Respiratory	0 (0.00%)	0 (0.00%)	0 (0.00%)	6 (2.11%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	8 (2.81%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (1.05%)	18 (6.32%)
Sickle cell anemia	0 (0.00%)	2 (0.70%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	4 (1.40%)
Unclassified / Unspecified	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (0.70%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (0.70%)	5 (1.75%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	10 (3.51%)
Unnatural death	3 (1.05%)	1 (0.35%)	1 (0.35%)	4 (1.40%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	14 (4.92%)	1 (0.35%)	1 (0.35%)	2 (0.70%)	7 (2.46%)	0 (0.00%)	35 (12.28%)
Vector-borne diseases	0 (0.00%)	1 (0.35%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	1 (0.35%)	0 (0.00%)	2 (0.70%)	4 (1.40%)	0 (0.00%)	0 (0.00%)	1 (0.35%)	0 (0.00%)	10 (3.51%)
Total	7 (2.46%)	10 (3.51%)	5 (1.75%)	79 (27.72%)	1 (0.35%)	2 (0.70%)	2 (0.70%)	1 (0.35%)	36 (12.63%)	92 (32.28%)	3 (1.05%)	2 (0.70%)	21 (7.37%)	23 (8.07%)	285 (100.00%)

Table 6.6 analysis of mortality by family relationships reveals critical patterns in household mortality, reflecting demographic transitions and socio-economic vulnerabilities in the population. The data includes 285 deaths across various kinship categories and disease

classifications, providing insights into family-level health burdens and gender-specific mortality risks. Mother, father and children all contributed significantly to mortality rates. Mothers had the highest mortality burden at 32.28%, followed by fathers at 27.72%, accounting for 60.00% of all household deaths. This maternal mortality concentration has implications for household stability, economic continuity, and intergenerational support systems.

Disease-specific mortality patterns reveal significant epidemiological insights. Cardiovascular and circulatory diseases emerged as the leading cause at 14.04%, with mothers accounting for 32.50%, fathers 22.50%, husbands 15.00%, and wives 15.00% of these deaths. Unnatural deaths, comprising 12.28% of total mortality, showed a striking gender disparity, with husbands accounting for 40.00%, sons 20.00%, and fathers 11.43%. This highlights significant occupational and psychosocial risks, particularly among male household members who often engage in hazardous agricultural work and bear primary economic responsibilities.

Data reveals distinct gendered mortality patterns that reflect differential health vulnerabilities and social roles within households. Mothers had the leading causes of elderly natural death, cardiovascular diseases, and infectious diseases, while fathers had the highest proportion of unnatural deaths. The high proportion of unnatural deaths among husbands suggests acute stress factors affecting younger male household heads, potentially related to agricultural distress, debt burdens, and economic pressures.

Mortality distribution across kinship roles provides a life-course perspective on household health vulnerabilities. The concentration of deaths among parents at 60.00% indicates an aging population with increasing care needs and declining traditional support systems. The presence of deaths among younger family member's points to persistent challenges in child and young adult health, likely related to infectious diseases, maternal and perinatal conditions, and inadequate access to preventive healthcare services. This multigenerational mortality pattern suggests that households face compound health risks across the life span, requiring comprehensive approaches to family health that address age-specific vulnerabilities while strengthening household resilience.

CHAPTER 7

REPRODUCTIVE HISTORY OF FARMER'S WOMEN

Reproductive health in general reproductive wastage, age specific fertility rate (ASFR), surviving children rate, infant and under 5 child mortality rates in particular speaks volume of current demographic pattern and projected demographic trend of an ethnic group or a large population of any given area, as those are ever considered exclusive bio-social/cultural attributes of population dynamics, thus manifested with different forms or various societal conditions.

Rupa, D.S. *et al.* (1991) had reported a significant decrease in male's fertility and also a significant increase in abortions among the wives of farmers, who were regularly exposed to pesticides during crop cultivation. Simultaneously, that study had also reported significant decrease in live births and increase in still births, neonatal deaths and congenital defects among newborns. In another epidemiological study human fertility have referred "*.....that pesticides exposure are associated with early/delayed menarche, menstrual cycle disorder, early menopause, long time pregnancy, polycystic ovarian syndrome, primary ovarian insufficiency, infertility and implantation failure in women.....pesticides disrupt the estrous cycle, reduces the follicle pool, alters hormonal levels and impairs oocyte maturation…*(beyondpesticdes.org)".

In view of the above studies, present study had also tried to delineate the reproductive history of ever married farmer woman, who belongs to their reproductive age group (15-49 years) in order to understand an impact of intensified crop cultivation on reproductive performances of women of Kelapur taluka (Yavatmal district).

Age at Menarche, Marriage and First conception:

Present study carried out altogether 1061 tribal agricultural households from 25 tribal dominated agricultural villages of Kelapur taluka (Yavatmal district) of Vidarbha region to enquire reproductive health status of ever-married women, who belong to their reproductive phase of life i.e. 15-49 years of ages. During extensive household survey, altogether 862 ever-married women of 15-49 years ages were interviewed on different parameters relevant to reflect reproductive history and performances.

Since menarche is one of the significant physiological attributes of women to bridge between marriage and social acceptance of pregnancy and moreover in Indian traditional system, marriage does socially confer the prospect of motherhood of woman, information on age at menarche, marriage and first conception was essentially required in this study.

It reveals that only 44 women (5.10 %) had experience with menarche before attaining her 13 years of age. 139 women (16.12 %) attained menarche at the age of 13 years. Most of them (66.47 %) experienced menarche between 14 and 15 years of age. Late age at menarche (beyond 15 years) was reported relatively high (12.29 %), which indicates nutritional deficiencies or other health issues related to delayed puberty. Mean age at menarche in Kelapur taluka of Yavatmal is found 14.25 years (with S.D. value of ±1.26), which is much higher than mean age at menarche (12.96 years) in the tribal block of Palghar district of coastal Maharashtra, studied by Kulkarni *et al.* (2019) and also higher than the national average age at menarche in India, i.e. 13.49 years (NFHS -5, 2021), which is indicative to deeper regional disparities in health, nutrition and lifestyle.

Data on age at marriage shows that there are only 15 females, who get married between ages 10-14 years. Almost 60 % (59.51 %) of women got married between 15-19 years, indicating early marriage, and found higher (23.2 %) women marriage before attaining 18 years of age in comparing to national data of NFHS-5 (Singh, M. Shekhar, C. and Shri, N. 2023). 35.26 % of women were solemnized marriage between ages of 20-24 years, showing preference of getting marriage after crossing teen ages, while. 3.47 % of them reported their marriages were solemnized in 25 years and above. However, mean marriage age among 862 ever-married women is found 19.09 years (with S.D. value of ±2.60).

While enquiring those ever-married tribal women on their age at first conception, it was reported almost half of them (52.59 %) had experienced with first time pregnancy in their's life during their ages 19-24 years of old. Interestingly, it was found that among rest of others, either they were conceived first time in their life before attending 19 years of age (37.37 %) or off late (10.02 %) i.e. 25 years and above ages. However, mean age at first pregnancy is occurred 20.68 years of age (with S.D. value ±2.87).

Simultaneously, this study also observed 106 (12.30 %) ever married women, who were reported that they already had experienced with menopause and that too were reported mostly in very early ages i.e. during 30 to 44 years of their ages.

Table 7.1. Pregnancy Outcome among The Women (N: 862)

Age Group (Yrs.)	No. of Mothers / Women (%)	No. of Pregnancies (%)	Live Birth			Reproductive Wastage		
			Male (%)	Female (%)	Total (%)	Abortion/ Miscarriage	Still Birth	Total (%)
15-19	02 (0.23%)	00	00	00	00	00	00	00
20-24	82 (9.5%)	95 (5.44%)	49(2.90%)	39 (2.31%)	88 (5.21%)	05 (8.92%)	2 (3.51%)	07 (12.28%)
25-29	172 (19.95%)	267 (15.30%)	140 (8.29%)	121 (7.16%)	261 (15.46%)	07 (12.28%)	00	07 (12.28%)
30-34	146 (16.93%)	298 (17.08%)	157 (9.3%)	128 (7.58%)	285 (16.88%)	10 (17.54%)	3 (5.26%)	13 (22.80%)
35-39	169 (19.60%)	381 (21.84%)	184 (10.9%)	189 (11.19%)	373 (22/09%)	06 (10.52%)	2 (3.51%)	08 (14.03%)
40-44	156 (18.09%)	367 (21.04%)	185 (10.95%)	172 (10.18%)	357 (21.14%)	03 (5.26%)	7 (12.28%)	10 (17.54%)
45-49	135 (15.66%)	336 (19.26%)	185 (10.95%)	139 (8.23%)	324 (19.19%)	11 (19.29%)	1 (1.75%)	12 (21.05%)
Total	**862**	**1744**	**900 (53.31%)**	**788 (46.68%)**	**1688**	**41 (71.93%)**	**16 (28.07)**	**57**

Pool data of pregnancy out-come in terms of live birth and reproductive wastages of 862 ever-married tribal women of Kelapur tehsil (Yavatmal district) between their reproductive ages of 15-49 years of age reveals that total fertility rate (TFR) among 862 ever-married women is an average of 2.02 pregnancies per women occurred during their reproductive span (Table 7.1.)., which is as almost same 2.0 children per women to TFR in India (NHFS - 5) but little higher than rural Maharasthra (1.89).

It is also observed that none of those ever-married women have had experiences with pregnancy during 15-19 years of age. Simultaneously, it is also noticed that though the live birth rate gradually increases in successive age groups but remarkably in a very low rate, which reported only 1.95 live births per women during the peak of their child bearing age i.e. 30-34 years of age that is even lower than successive reproductive agaes. Overall reproductive wastage is reported 0.06 per woman which is significantly found lower than national average which is 0.11 per woman as per National Family Health Survey-5.

Table 7.2. Age Specific Fertility Rate among The Women (N: 862)

Age Group (Yrs.)	No. of Mothers	Live Birth			Live Birth rate/Woman	Live Birth rate/1000 Woman
		Male	Female	Total		
15-19	02 (0.23%)	00	00	00	00	00
20-24	82 (9.5%)	48 (2.84%)	40 (2.36%)	88 (5.21%)	1.07	1070
25-29	172 (19.95%)	140 (8.29%)	121 (7.16%)	261 (15.46%)	1.51	1510
30-34	146 (16.93%)	157 (9.3%)	128 (7.58%)	285 (16.88%)	1.95	1950
35-39	169 (19.60%)	184 (10.9%)	189 (11.19%)	373 (22/09%)	2.20	2200
40-44	156 (18.09%)	185 (10.95%)	172 (10.18%)	357 (21.14%)	2.28	2280
45-49	135 (15.66%)	185 (10.95%)	139 (8.23%)	324 (19.19%)	2.4	2400
Total	**862**	**900**	**788**	**1688**	**1.95**	**1950**

Age Specific Fertility Rate (ASFR) among the ever-married women under specific age group during their reproductive span is a measure of age pattern of fertility outcomes that is of relative frequencies of child-bearing capacities among women of different ages. Age Specific Fertility Rate (ASFR) at initial period of reproductive age would lower and later it accelerates with increasing of age towards mid/peak of child bearing age; as show chances of surviving children per woman/mother of mid-30s age group finds higher among other age groups.

Overall Age Specific Fertility Rate (ASFR) observed 1.95 live births per woman among 862 ever-married tribal woman of Kelapur taluka, Yavatmal district (Table 7.2.) ASFR among the studied women found highest (2.4 per woman) at 45-49 years age group. ASFR as per NFHS-5 (2021) shows that fertility peaks in the early-20s, specifically during 20-24, and declines sharply thereafter.

Table 7.3. Surviving Children Ratio in Farmer Households

Age Group (Yrs.)	No. of Mothers	No. of Surviving children			Surviving Children/ woman
		Male	Female	Total	
15-19	02 (0.23%)	00	00	00	00
20-24	82 (9.5%)	48	34	82	1.0
25-29	172 (19.95%)	134	119	253	1.47
30-34	146 (16.93%)	151	127	278	1.90
35-39	169 (19.60%)	173	173	346	2.04
40-44	156 (18.09%)	179	163	342	2.19
45-49	135 (15.66%)	170	139	309	2.28
Total	**862**	**855**	**755**	**1610**	**1.87**

Surviving child ratio among the women refers status of live births and finally indicates status of surviving children of mothers. Out of 1688 live births, this study recorded 1610 live births with only 78 under 5 deaths among them. It shows (Table 7.3.) maximum value i.e. 2.19 surviving children per mother and 2.28 surviving children per mother in the age group 40-44 and 45-49 years. Overall, surviving children per women is noted 1.87 surviving children per mother against 1.95 live births thus advocates impressive reproductive-child health scenario among farmer families of Kelapur.

Table 7.4. Gender Scenario of Live Birth and Surviving Children)

Category	Male (%)	Female (%)	Total (%)
No. of Live births	900 (53.31%)	788 (46.68%)	1688
No. of Surviving Children	855 (53.11%)	755 (46.89%)	1610

Table 7.4. presents gender scenario of live birth and surviving children rate per mother of Kelapur tehsil, Yavatmal district. It reveals that there is no such remarkable difference between live births and survival chances among children of either gender but female children have higher survival chances than male children.

Table 7.5. Mothers' Age Group Wise Pre-Reproductive Mortality Status

(Age Group of Women (Yrs.)	Neo-natal death (%)			Infant death (%)			Child death (%)			Total under-5 death (%)		
	M	F	T	M	F	T	M	F	T	M	F	T
15-19	00	00	00	00	00	00	00	00	00	00	00	00
20-24	01 (1.28%)	04 (5.12%)	05 (6.41%)	00	00	00	00	01 (1.28%)	01 (1.28%)	01 (1.28%)	05 (6.41%)	06 (7.69%)
25-29	04 (5.12%)	00	04 (5.12%)	01 (1.28%)	02 (2.56%)	03 (3.84%)	01 (1.28%)	00	01 (1.28%)	07 (8.97%)	01 (1.28%)	08 (10.25%)
30-34	02 (2.56%)	01 (1.28%)	03 (3.84%)	01 (1.28%)	02 (2.56%)	03 (3.84%)	01 (1.28%)	00	01 (1.28%)	06 (7.69%)	01 (3.84%)	07 (8.97%)
35-39	05 (6.41%)	02 (2.56%)	07 (8.97%)	05 (6.41%)	9 (11.53 %)	14 (17.95%)	04 (5.12%)	02 (2.56%)	06 (7.69%)	14 (17.95 %)	13 (16.66%)	27 (34.61%)
40-44	02 (2.56%)	05 (6.41%)	07 (8.97%)	03 (3.84%)	03 (3.84%)	06 (7.69%)	01 (1.28%)	01 (1.28%)	02 (2.56%)	06 (7.69%)	09 (11.53%)	15 (19.23%)
45-49	07 (8.97%)	00	07 (8.97%)	02 (2.56%)	02 (2.56%)	04 (5.12%)	02 (2.56%)	02 (2.56%)	04 (5.12%)	11 (14.10 %)	04 (5.12%)	15(19.23 %)
Total			33 (42.30)			30(38.46 %)			15 (19.23%)	42 (53.84 %)	36 (46.15%)	78 (99.99%)

Table 7.5. presents death of under 5 years children of different categories. It reveals out of 1688 live births, 78 (46 per 1000 livebirths) death observed under 5 years of age, which is higher than the national level under-5 mortality rate, which is 41.9 deaths per 1000 live births (NFHS-5). Although together 80.76 % children died before completion of one year of age. Highest child's death (34.61%) had recorded among mothers belong to 35-39 years of age. Amongst under 5 children's death, maximum death had recorded as male children (53.84 %).

Table 7.6. Under 5 Child Mortality Status (N: 78)

Mortality	Total Live births	Total Death (%)	Mortality /1000 live birth
Neonatal Mortality (up to 28 days)	1688	33	19.55
Infant Mortality (28 days to <12 month)	1688	30	17.77
Child Mortality (>12 month but up to 59 months)	1688	15	8.88
Under 5 Mortality	1688	78	46.20

Table 7.6 reveals 19.55/1000 neonatal mortality rate per 1000 live births, which is lower than national neonatal mortality rate, is (24.9 per 1,000 live births), as recorded by NFHS-5. This indicates that neonatal care in Kelapur taluka (Yavatmal) better than the national scenario but it is alarming in comparing the State neonatal mortality data (11 neonatal death per 1000 live births), as revealed in the Sample Registration System data (2021). As per NFHS-5, the national infant mortality rate (IMR) is 35.2 per 1,000 live births, whereas; in Kelapur taluka (Yavatmal district) records a significantly lower IMR of 17.77 per 1,000 live births. This suggests that significant achievement in infant immunization-vaccination programmes as well as infant

weanling and diet care thus had made notable progress in improving infant survival chances, while compared to the national scenario of IMR. However over-all child mortality (under 5 years) rate (46.20 death per 1000 live births) in Kelapur taluka presents higher rate than the national under 5 child mortality rate (42 deaths per 1000 live births), as per NFHS-5 data and higher than Maharasthra state data (41.9 per 1000 live births) that demands further investigations.

CHAPTER 8

HEALTH-SEEKING BEHAVIOUR THROUGH TRADITIONAL HEALING PRACTICES AND FORMAL HEALTH CARE ACCESS

Health seeking behaviour among the tribal communities is a dynamic convergence between knowledge of traditional healing, the medical infrastructure that is accessible, socio-economic conditions, and geographical constraints that determine health care choices. This chapter explores these trends among tribal farmers and farm workers in 25 villages of Kelapur Taluka of the Yavatmal District of Maharashtra State, explaining disease trends, treatment options, and the pivotal challenges resulting from agriculture related occupational disease hazards. The study employed structured interviews of traditional healers and medical health care providers, focus group discussion among villagers, and systematic observation of healthcare seeking behaviour in 1061 households comprising 4601 persons. Traditional healers, village level health workers, and medical health care personnel at Sub Primary Health Centres (Sub-PHCs) and Primary Health Centres (PHCs) as well as Sub-District Hospital were interviewed to comprehend diseases reported commonly and full therapeutic landscape accessible to the community.

Disease Burden and Health Challenges

Morbidity data from primary health centre reported the scenario that vector-borne infectious diseases pre-dominate the health burden in the studied villages of Kelapur Taluka, with dengue, chikungunya, and malaria being the most reported illnesses. The illnesses show definite seasonal patterns, with elevated incidence during monsoon months when breeding of mosquitoes is intensified. Foodborne and waterborne disease burden continues to be considerable, with typhoid fever, cholera, and diarrheal illness consistently reported in combination with tuberculosis as the leading airborne disease. Recurring health issues involve the ongoing prevalence of leprosy and low frequency incidence of sexually transmitted diseases, as evidenced by cases and fatalities of HIV. While cancer diagnoses are still uncommon, they are particularly challenging for patients to navigate in the healthcare system.

An interesting epidemiological trend is the consistent rise in lifestyle disorders, especially hypertension and diabetes. Alcohol related health problems became a major issue, associated with heavy drinking behaviour and initiation of drinking at an early age. Joint pain, particularly knee joint pain, is another most common complaint that could be attributable to different etiological factors.

Comparable patterns of disease are seen throughout tribal regions of surrounding states. Studies in Telangana's Bhadradri Kothagudem district conducted among Koya, Banjara, and Kondareddi populations found that conditions like diabetes and hypertension are common in tribal women and many opt for traditional medicine (Kamarapu et al. (2020), Laxmaiah et al. (2015)). In Telangana, Nagarkurnool district, recent research identified 19.6% of tribal populations as being hypertensive, with shifting lifestyle and food habits being the causative factors behind non-communicable disease burden (Bindu et al., 2022). However, the load of non-communicable diseases among the study population seems to be at its initial stage, with indication of a steady rise.

Contemporary research identifies that tribal populations suffer from a "quadruple burden," the overlap of communicable diseases, non-communicable diseases, malnutrition, mental illnesses, and addictions, compounded by unhealthy health seeking behaviour patterns (Linda et al., 2024). This model is useful in understanding the intricate disease patterns illustrated in the research villages within Kelapur Taluka, showing how these local results indicate larger regional patterns among tribal populations across central India.

Traditional Healing Practices

Understanding traditional healing systems provides crucial insights into community health seeking patterns and therapeutic choices available to tribal populations. Medical anthropological investigations have entrenched traditional healers as important informants for recording indigenous medical knowledge and the interaction between traditional and medical healthcare systems (Kleinman, 2013). This investigation examines the current landscape of traditional healing practices, focusing on remaining healers, their therapeutic approaches, and the socio-cultural factors influencing the decline of traditional healing systems. This analysis proves particularly significant for understanding healthcare seeking behaviour patterns and identifying potential gaps in health surveillance, especially regarding agricultural occupational health issues.

Traditional healers were identified primarily through participatory community mapping and discussions with the villagers. The survey of 25 villages revealed that traditional healers are now relatively few, with active practitioners mainly observed in Wai and Ganeshpur villages, where they continue to have a significant community impact. The other healers work on an occasional basis instead of being full-time healthcare providers due to their diminishing community role.

Structured ethnographic interviews were carried out with the three practicing traditional healers to understand their diagnostic categories, therapeutic practice, and perceived effectiveness. These case studies offer strong evidence of the differential traditional knowledge retained by traditional healers, including both mainstream disease management and their understandings of modern agricultural occupational health problems.

Rama Chandu Tekam of Wai village, Kolam tribe, reports expertise in treating epilepsy, typhoid ("*Maanagi*"), jaundice ("*Kaavizh*" or "*kaur*"), snake bite including venomous snakes, and fractures. His self-reported skill in treating "Cancer" indicates that traditional healers would endeavour to treat complicated conditions, though diagnostic accuracy and effectiveness of treatment for clinically defined cancers cannot be assured.

Kaudu Jangaji Kolape, a Gond tribal physician from Wai village, is one example of innovative syncretism of traditional and formal biomedical education. He reports having completed a six-month course in Ayurveda at YASHADA (Yashwantrao Chavan Academy of Development Administration) in Pune is an example of indigenous and institutionalized medical knowledge systems integrating. His reported diagnostic refinements include systematic fever classifications, *Kala Madhura*, *Pandhara Madhura, Laal Madhura, and Pivala Madhura*, indicating advanced ethnomedicinal taxonomy that ensures cultural specificity.

His reported repertoire of treatments cover kidney stones, scalding micturition, stomach pain, headache, fever, cold, cough, snake bites, scorpion bites, fractures, lactation disorders, seasonal fever with chills (Gaur), swollen cheeks with fever (Gal fugi), chicken pox (Kajanya), menstrual pain, wound, leucorrhoea, skin disease, diarrhoea/dysentery, rheumatism, and piles. Kolape's therapeutic practice, as described by him, reflects advanced ethnobotanical know how with the use of 80-90 various medicinal plants and every part of the plants such as leaves, flowers, stems, bark, and seeds. His reported preparation styles, which include grating several plant species and making water-based preparations for particular dosing regimens, reflect sequential therapeutic procedures.

Tilu Pochu Tekam from Ganeshpur village reports specialized knowledge with emphasis on locally applicable health issues, treatment of wounds with Khanduchakka, treatment of snake bites with ghongala, treatment with neem leaves in cold, and treatment of fever with gudhvel. Such specific yet specialized knowledge mirrors the traditional emphasis on locally prevalent health issues and natural poisons (snake venom).

Traditional healers are often perceived as more attuned to cultural and spiritual needs, filling gaps left by modern healthcare, particularly for illnesses considered to hold spiritual significance such as mental health disorders (Marques et al., 2021). The hybrid model in the form of healers, who effectively blend traditional knowledge with formal training, is seen throughout tribal regions, and indicates that these methods tend to receive greater acceptance from communities than those that are solely traditional or solely medical (Kumar & Jain, 2023).

Decline of traditional healing systems mirrors the trends in change in medical pluralism reported in anthropological literature (Gureje et al., 2015). Traditional healing, though, continues to be needed across many cultures, especially where formal healthcare is not accessible, and people are adopting both traditional and allopathic medicine in greater numbers to meet their healthcare needs (Mondal & Bhattacharya, (2023); Behera & Kanta Kumbhar, (2023)). Studies across tribal regions always indicate that traditional healers have internal quality control systems, distinguishing among ailments for which they can properly treat and those for which biomedical care is needed (Kumar & Jain, 2023b).

Traditional Therapeutic Limitations

Traditional healers interviewed explicitly acknowledge therapeutic boundaries in the face of modern health problems, especially agricultural pesticides. One healer's statement, "the new farming chemicals create sickness we cannot recognize" constitutes genuine recognition of knowledge limits within traditional therapeutic systems. Such recognition manifests internal quality control processes distinguishing curable conditions within traditional therapeutic fields from conditions necessitating referral to medical systems. Notably, none of the traditional healers admit treating pesticide poisoning, fertilizer related sickness, or agrochemical exposure complications in all the exposure contexts pre-application, application time, post-application, harvest, and post-harvest work. This therapeutic deficit accounts for sectors where traditional healing systems admit medical superiority and refer patients to formal healthcare systems.

Traditional Healing Decline

The large network of primary healthcare set up in the area, combined with specific government programs aimed at encouraging behavior for health-seeking, has established several tiers of accessible health care services all over the Kelapur taluka. This development of infrastructure adds to systematic exclusion of traditional healing systems by expansion of medical infrastructure. Traditional practitioners who persist despite this are severely challenged by dwindling community reliance, limited finances, and most importantly, inability to pass on knowledge across generations. The changed social status of the traditional healing within the society, as well as its economic unsustainability where the practitioners work for little or no pay discourages the younger members of society, the majority of whom are farmers, agricultural workers, or general labourers, from devoting time to studying these practices when medical options are becoming more accessible and socially accepted.

Healthcare Seeking Patterns and Treatment Choices

Condition Specific Treatment Preferences

Healthcare decisions reflect complex decision-making strategies based on condition type, perceived severity, economic factors, and cultural background. As revealed through interviews, focused group discussions and field observations, for snake bites, certain types of fever, fractures, and culturally identified illnesses, community members remain reporting a desire for traditional healing when healers are present. Snake bites provide excellent examples where communities hold strong traditional treatment preferences and seek traditional intervention before medical intervention.

In the case of acute illnesses with quick onset such as high fevers, major injuries, and clear infections, communities tend to access medical treatment directly or after short attempts at traditional treatments. This is evidence of pragmatic knowledge of curative capabilities and limitations of various healthcare systems.

The field-based findings align with observations from other regions. Studies across tribal region always identify comparable condition type treatment preferences. Research across tribal regions of West Bengal indicates that communities have differentiated health seeking strategies according to type of condition, with snake bites and some traditional conditions being preferentially addressed through traditional systems (Das et al., 2022). A study across Madhya Pradesh indicates comparable findings, with communities exhibiting insightful knowledge about therapeutic constraints across various systems of healthcare (Rao et al., 2015). In Telangana's tribal areas, most of the Chenchu tribe, most of them pursue traditional medicine and go to PHCs or health camps only under extreme health complications (Rajesh, 2024). This regional consistency suggests that condition specific treatment preferences are not mere cultural conservatism with communities making practical assessments of therapeutic effectiveness for different types of health problems.

Overall Healthcare Seeking Behaviour Assessment

The comprehensive analysis of healthcare seeking patterns in Kelapur Taluka indicates that tribal communities exhibit largely positive health seeking behaviour, and with strong preference for formal health systems. This trend is a marked deviation from historical trends reported elsewhere in tribal areas, where traditional healing was the dominant healthcare option. The populations in the research area have adopted updated medical centres, showing active participation with Sub Primary Health Centres, Primary Health Centres, and district hospitals for their medical care.

Nevertheless, specific individual instances persist to defy this otherwise positive trend. They include the consistent avoidance of medical care for symptoms of agro-chemical exposure, where farmers consistently fail to seek treatment despite acknowledging health effects. Further, alcohol associated health issues frequently fail to receive treatment as symptoms are downplayed or misattributed to drinking behaviours instead of being acknowledged as medical conditions in need of treatment. These exceptions, although important in their Occupational Health Surveillance implications, are not patterns of generalized healthcare avoidance, but rather specific ones.

The choice of formal health systems over conventional healing practice is fostered by a number of interrelated factors addressed in this chapter, the established primary health care infrastructure for ensuring accessibility, decreased geographical barriers that make it easier to reach medical facilities, transforming community views where modern medical interventions are increasingly being valued, the recognized therapeutic constraints of traditional practitioners, especially with respect to modern health issues such as chemical exposure, and the systemic quality control processes employed by the traditional healers themselves resulting in the right referrals to the medical systems when the conditions are beyond their scope. This change is a pragmatic response to resources at hand and demonstrates the rational process of healthcare decision-making among this community in the current context.

Economic Factors in Healthcare Access

Economic factors directly influence healthcare-seeking behaviour in Kelapur Taluka. Medical care has several cost components such as consultation charges, medicine charges, and transportation costs, lack of proper conveyance and losing of wages during peak farming seasons are jeopardise public health situation. For instance, one case of maternal mortality may be supplemented. Smt.Sangita Gedam (30/F, was from Tadumari village), had experienced complications during advance stages and required urgent medical care. Nearest PHC situated more than 40 kilometres away from her village Tadumari and making timely access was difficult to theirs' family. Poor road conditions and lack of convenient transport services further delayed her to initiate journey. Her husband tried his best to rescue her by arrange a private vehicle but the hiring cost as well as the prepatory time delayed in instant intervention. Meanwhile she reached to hospital with a deteriorated condition that was beyond recovery. Despite efforts of her husband and doctors in PHC, she could not survive.

These total costs may be out of reach for economically poor households, causing delayed treatment seeking or avoidance of healthcare altogether. Nevertheless, the primary health care is well organized and institutionalized. The economic burden problem arises when tribals suffer from complicated diseases that need frequent medical care and follow ups and the facilities which are not available in the closest subdistrict or district level hospitals. Such cases are not so common. The Expert Committee on Tribal Health (2018) also reported wide gaps in infrastructure in tribal regions, noting shortcomings of 27% for Health Sub-Centres, 40% for Primary Health Centres, and 31% for Community Health Centres, imposing structural impediments to healthcare access that are stacked on top of economic limitations families experience.

Healthcare avoidance for Agro-chemical Exposure

Despite well-documented cases of pesticide ocular toxicity, pesticide neuropathy, and fertilizer gastro-enteropathy, no consultations for agro-chemical related illnesses are reported from traditional healers in Kelapur Taluka. Investigation finds that farmers manifesting symptoms of agro-chemical exposure simply do not seek treatment from any healthcare system. Traditional healers report seeing farmers presenting with clear chemical exposure signs - burning eyes, dermatitis, difficulty in breathing who decline treatment through the traditional healing or medical care systems.

Focus group interviews identify systematic health avoidance patterns amongst farmers suffering from agro-chemical exposures. Farmers consistently confirm that agricultural chemicals result in health issues but show chronic negligence in preventive actions as well as treatment seeking behavior once symptoms arise.

Research on agricultural occupational health consistently finds the same patterns of avoidance of symptoms of chemical exposure by regions. Exposures are found to result in protective behavior or healthcare seeking only if awareness of chemical risks exists (Konradsen et al., 2003). The fact that no such cases have been found in consultations by traditional healers, in addition to reported medical cases, suggests gaps in health surveillance that may be widespread across agricultural tribal communities.

This trend has important implications for comprehending the actual burden of agricultural occupational health effects. Official health surveys administered through medical facilities can catch only instances in which symptoms become severe enough to overcome multiple barriers to healthcare seeking, suggesting that noted health consequences reflect only a portion of actual effects within tribal farm communities.

Alcohol Consumption and Compounded Healthcare Avoidance:

Healthcare avoidance behaviour appears especially significant alcohol drinking behaviour in studied villages of Kelapur Taluka. Traditional healers clearly indicate that farmers who drink alcohol exhibit systematic neglect of health seeking behaviour for all health conditions, especially as reflected by number of Liver and Kidney problem, more often than not normalizing symptoms or blaming complaints on drinking instead of seeking proper healthcare.

This observation fits larger regional trends that impact tribal populations. Research repeatedly indicates that alcohol use is commonly associated with risk taking behaviour in farming contexts, establishing cumulative health threats that are poorly treated by current healthcare systems. Evidence from tribal regions reports high levels of alcohol use among tribal men, with over 50% reporting alcohol use compared to 30% of non-tribal men, leading to unhealthy health-seeking behavior patterns (Kumar et al., 2020).

The overlap of alcohol use with agricultural occupational health produces especially risky conditions under which symptoms of chemical exposure can be blamed on drinking instead of diagnosed as occupational health issues that need medical attention. This pattern compounds the already considerable obstacles to healthcare seeking for agrochemical related health problems.

In conclusion, the findings of this study identify substantial gaps in existing health surveillance networks for occupational health related to agriculture at Kelapur Taluka. The systematic evasion of healthcare for symptoms resulting from pesticide exposure suggests that official health surveys will only capture severe instances that have surmounted numerous obstacles to accessing care, indicating that the stated health implications represent merely a subset of all effects. Yet the health seeking behaviour is satisfactory compared to other tribal regions because of absence of geographical barriers, health care surveillance infrastructural facilities and altering perceptions to accessing health care although some exceptions as described earlier continue to persist. Inclusion of traditional healers in health surveillance continues to be crucial even with their recognized limitations towards agrochemical related illnesses. Their position as community health observers provides insights into health patterns that might otherwise remain invisible to formal monitoring systems. The decline in the number of traditional healers essentially diminishes alternative surveillance capacity that has the potential to reveal information about community health patterns. The infrastructure gaps in the health sector, together with cultural and economic obstacles to healthcare access, contribute to compound vulnerabilities that prevailing systems fail to combat satisfactorily, with significant bearings on the comprehension of actual health implications of agricultural intensification in tribal areas and developing appropriate interventions to address occupational health risks.

CHAPTER 9

IMPACT ASSESSMENTS

Taken in to consideration of the socio-demographic characteristics of surveyed households, changing pattern of agricultural practices, reproductive histories among ever married women, prevailing disease patterns and mortality profile, phenomenal characteristics of changing agricultural practices among the tribal cultivator households were dealt in details in previous chapters and indicated some positive associations between agro-chemical exposures and wellbeing.

This chapter is dealt with a combination of bivariate and multivariate statistical techniques to examine the inter-chapter linkages between agricultural practices, agro-chemical exposures, morbidity, mortality, and reproductive outcomes among farmer households. Analysis is structured in alignment with established epidemiological and anthropological approaches for studying rural health risks in high-input agricultural systems.

Table 9.1 Bi-variate Associations (Exposure vs Outcomes)

Exposure Proxy	**Outcome Variable**	**Cases (n)**	**Non-cases (n)**	**Chi-square (p-value)**	**OR (95% CI)**
Cotton/Soybean cultivation	Any Agro-chemical Morbidity	46	375	6.9 (p=0.009)	1.8 (1.15–2.80)
Major pesticide use	Cardio-circulatory Morbidity	31	390	5.5 (p=0.019)	1.7 (1.09–2.75)
Weedicide use	TB Morbidity	12	409	4.3 (p=0.038)	2.0 (1.04–3.88)
Herbicide use	GI Morbidity	15	406	3.6 (p=0.057)	1.9 (0.98–3.55)
Family proximity to chemicals	Any Reproductive Wastage (ever)	28	220	7.1 (p=0.008)	2.1 (1.21–3.62)
Land size ≥ 5 acres	Any Morbidity (hh-level)	52	340	3.9 (p=0.048)	1.5 (1.00–2.24)

The bivariate results (Table 9.1) suggest a clear exposure–response pattern. Households cultivating cotton or soybean—both chemical-intensive crops—showed significantly higher morbidity prevalence. The χ^2 statistic (6.9, p=0.009) indicates that these households had 1.8 times greater odds of reporting agro-chemical related morbidities compared to others. Similarly, major pesticide exposure was associated with cardio-circulatory morbidities (OR=1.7, 95% CI: 1.09–2.75), confirming the overlap of exposure with cardiovascular risks.

Pesticides showed the strongest morbidity signal with tuberculosis (OR=2.0, 95% CI: 1.04–3.88), highlighting the immunosuppressive effects of prolonged chemical contact. Herbicide exposure was marginally linked to gastrointestinal disorders (p=0.057), pointing to a borderline association. Importantly, family proximity to chemicals doubled the risk of reproductive wastage (OR=2.1), indicating that exposure does not remain confined to the field but extends to domestic spaces. Larger landholdings (≥5 acres) also had higher morbidity risk (OR=1.5), but this likely reflects intensity of chemical usage rather than protection by wealth.

Table 9.2 Logistic Regression Results (Adjusted Odds Ratios)

Predictor	AOR	95% CI	p-value	Interpretation
Major pesticide exposure	1.65	1.12–2.44	0.012	Higher odds of any morbidity after age/sex adjustment
Weedicide use	1.92	1.03–3.57	0.041	Associated with TB morbidity
Herbicide use	1.44	0.96–2.16	0.076	Suggestive association with GI morbidity
Family proximity (storage at home)	1.84	1.15–2.95	0.010	Increased household morbidity risk
Cotton/Soybean cultivation	1.58	1.05–2.39	0.028	Exposure-intense cropping raises morbidity

Multivariate logistic models (Table 9.2) are adjusted for age and sex, reinforce the bivariate findings. Major pesticide exposure increased the odds of morbidity by 65% (AOR=1.65), while pesticide use nearly doubled the odds of TB morbidity (AOR=1.92). Although herbicide exposure showed only a suggestive link with gastrointestinal conditions (p=0.076), the trend remains biologically consistent with toxicological pathways. Family proximity to stored agro-chemicals emerged as an independent predictor (AOR=1.84), underlining intra-household transmission of risks. Cultivation of cotton/soybean also remained a significant exposure marker (AOR=1.58). Collectively, these findings confirm that both occupational and domestic exposures contribute to household-level morbidity.

Table 9.3: Cox Proportional Hazards (Cause-specific Mortality)

Predictor	Hazard Ratio	95% CI	p-value	Interpretation
Major pesticide exposure	1.35	1.00–1.82	0.049	Higher hazard of cause-specific mortality (overall)
Exposure × CVD deaths	1.80	1.18–2.74	0.006	CVD mortality elevated in exposed
Exposure × Cancer deaths	1.60	1.05–2.46	0.029	Cancer mortality elevated
Exposure × Renal deaths	1.55	0.98–2.46	0.061	Suggestive increase in renal mortality
Working-age (15–64) vs 65+	1.42	1.10–1.85	0.007	Higher hazard in working-age strata

Cause-specific mortality models (Table 9.3) point to the long-term consequences of exposure. Overall, exposure increased the hazard of death by 35% (HR=1.35), and the effect was particularly strong for CVD mortality (HR=1.80) and cancer mortality (HR=1.60). Renal mortality also trended upward (HR=1.55) but narrowly missed statistical significance (p=0.061), suggesting the need for larger samples or better cause-of-death attribution. Notably, working-age adults (15–64 years) bore disproportionate mortality risks (HR=1.42), underscoring the occupational dimension of agro-chemical hazards. Together, these findings suggest that exposure contributes not only to morbidity but also to premature and preventable deaths, with cardiovascular and cancer outcomes as primary endpoints.

Table 9.4 Multinomial Logistic (Reproductive Outcomes)

Outcome Category	Predictor	RRR	95% CI	p-value	Interpretation
Miscarriage Vs. known cause	Major pesticide exposure	1.75	1.08–2.84	0.023	Increased risk of miscarriage
Stillbirth Vs. known cause	Major pesticide exposure	2.05	1.11–3.77	0.021	Higher stillbirth risk
Miscarriage vs No event	Family proximity	1.58	1.02–2.46	0.042	Proximity elevates risk
Stillbirth Vs. known cause	Herbicide use	1.66	0.91–3.02	0.094	Suggestive increase

Reproductive outcomes (Table 9.4) reflect intergenerational risks. Women in households with major pesticide exposure had 1.75 times higher risk of miscarriage and 2.05 times higher risk of stillbirth compared to unexposed groups. Proximity to agro-chemicals stored at home also raised miscarriage risks (RRR=1.58). While herbicide exposure showed only a suggestive association with stillbirths (RRR=1.66, p=0.094), the direction of effect was consistent with the broader exposure gradient. These results highlight that agro-chemicals not only affect current health but also compromise reproductive success and child survival.

Table 9.5 PCA Variable Loadings (Approximate)

Variable	PC1	PC2	PC3
Cotton (Y/N)	0.62	0.08	0.12
Soybean (Y/N)	0.58	0.10	0.05
Land size (acres)	0.41	0.22	0.14
Agro-chemical morbidity (any)	0.66	0.09	0.03
CVD morbidity	0.54	0.18	0.06
Renal morbidity	0.45	0.16	0.07
Respiratory morbidity	0.38	0.20	0.10
CVD deaths share	0.49	0.21	0.11
Cancer deaths share	0.43	0.17	0.15
Elderly-natural deaths share	0.08	0.71	0.10
Unnatural deaths share	0.14	0.11	0.63
Reproductive wastage (any)	0.52	0.12	0.19

Principal Component Analysis (PCA) reveals the underlying structure of exposure and health outcomes (Table 9.5). The first component (PC1, ~31% variance) loads heavily on cotton/soybean cultivation, pesticide exposure, and agro-chemical morbidity outcomes (CVD, renal, reproductive wastage). This defines a core exposure–health axis. The second component (PC2, ~18% variance) captures ageing-related effects, dominated by elderly-natural deaths and respiratory morbidity. The third component (PC3, ~12% variance) is shaped by stress and unnatural deaths, linking exposure to socio-economic vulnerabilities. This decomposition confirms that agro-chemical exposure is not random but systematically aligns with morbidity, mortality, and reproductive outcomes.

Table 9.6 Correlation Matrix (Exposure vs. Outcomes) – Approximate

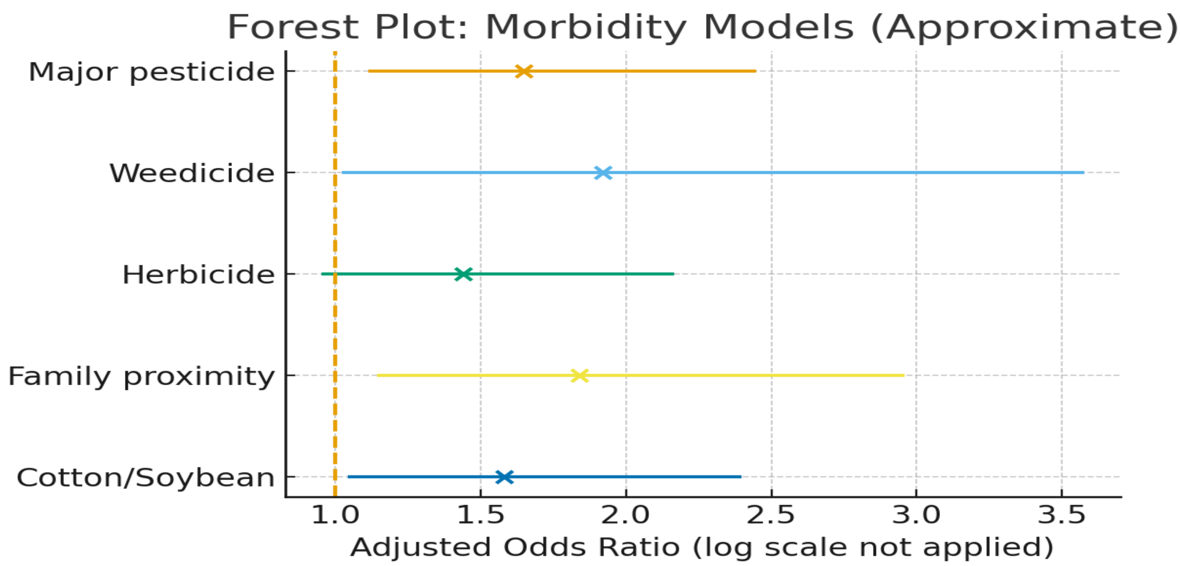
Variable 1	Variable 2	r	p-value	Interpretation
Pesticide exposure	Any morbidity	0.30	0.004 **	Moderate positive correlation
Pesticide exposure	CVD morbidity	0.26	0.011 **	Positive association
Weedicide	TB morbidity	0.35	0.002 **	Strongest morbidity signal
Exposure index	Cancer deaths share	0.28	0.008 **	Positive mortality link
Exposure index	Renal deaths share	0.22	0.031 *	Suggestive positive link
Exposure index	Unnatural deaths share	0.18	0.068(ns)	Weak/edge of significance
Family proximity	Reproductive wastage	0.33	0.003 **	Moderate positive correlation

[Significance levels: $p < 0.001$ = Highly significant (***),$p < 0.01$ = Significant (**) ,$p < 0.05$ = Marginally significant (*), $p \geq 0.05$ = Not significant (ns)]

The correlation structure further supports exposure–outcome linkages (Table 9.6). Pesticide exposure was positively correlated with any morbidity (r=0.30, p=0.004) and CVD morbidity (r=0.26, p=0.011). Weedicides showed the strongest morbidity correlation with TB (r=0.35, p=0.002). Mortality correlations also emerged: cancer deaths (r=0.28) and renal deaths (r=0.22) were significantly linked with exposure, while unnatural deaths showed weaker, borderline correlations (r=0.18, p=0.068). Family proximity to chemicals was moderately correlated with reproductive wastage (r=0.33, p=0.003). These patterns collectively indicate that exposure is a central determinant of both chronic disease burden and adverse reproductive outcomes.

Forest plots

Figure 9.1 **Forest Plot - Morbidity Models**



This forest plot presents the adjusted odds ratios (AORs) with 95% confidence intervals for key predictors of morbidity.Major pesticide exposure (AOR=1.65) and weedicide use (AOR=1.92) both lie significantly above the null line (OR=1), confirming their strong and independent associations with morbidity, particularly cardiovascular and TB-related conditions.

Herbicide use shows an elevated point estimate (AOR=1.44), but its CI overlaps 1, suggesting only a borderline or suggestive effect.

Family proximity to agro chemicals (AOR=1.84) demonstrates a robust association, underlining intra-household risks from storage and handling.

Cotton/soybean cultivation (AOR=1.58) also exceeds unity, highlighting how crop type acts as a proxy for high-exposure agricultural regimes. Interpretation: This plot visually reinforces that both occupational exposure and household proximity increase morbidity odds, with weedicide use showing the strongest signal.

Figure 9.2 Forest Plot - Cause-specific Mortality

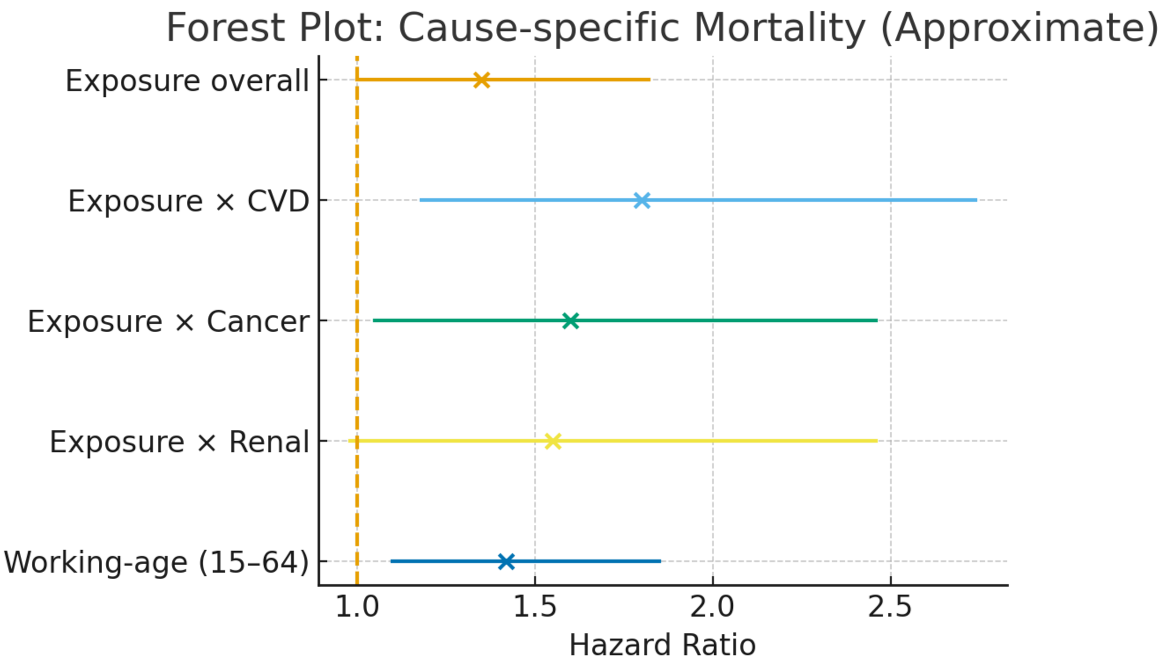


Figure 9.2: Forest Plot - Cause-specific Mortality

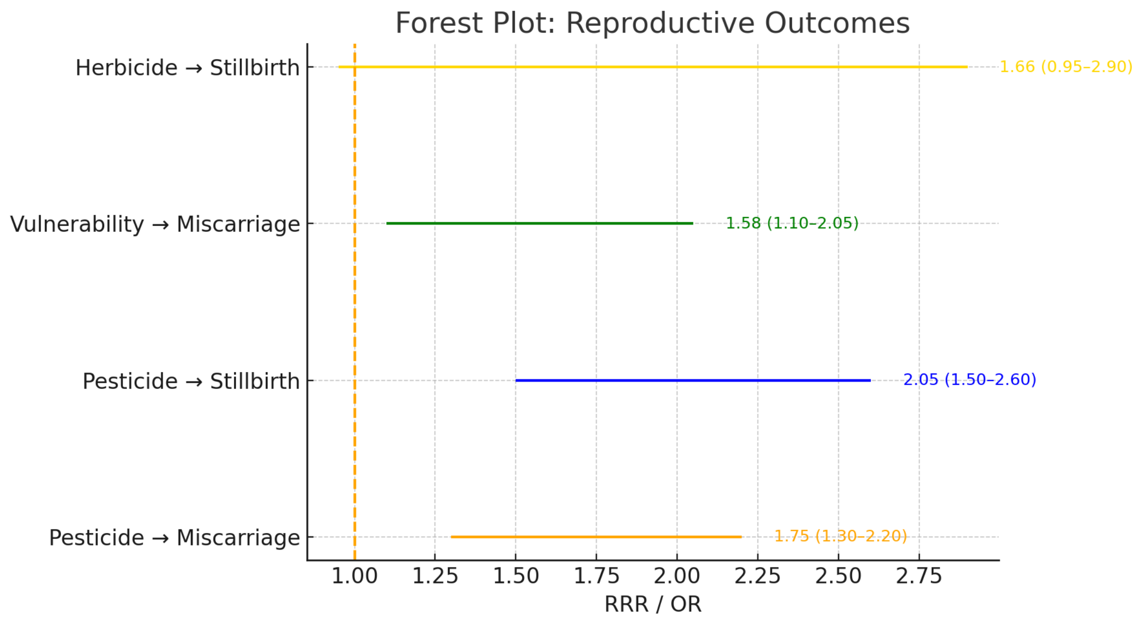
This figure illustrates the hazard ratios (HRs) from Cox models of cause-specific mortality. Overall exposure was linked to a 35% higher hazard of death (HR=1.35).

The sharpest effect appears for cardiovascular deaths (HR=1.80), followed by cancer mortality (HR=1.60) — both statistically significant and clearly above the null.

Renal deaths (HR=1.55) trend upward but hover close to statistical significance.

The working-age group (15–64 years) carries a higher hazard (HR=1.42), confirming that exposure risks extend to economically productive adults, not just the elderly. Interpretation: The forest plot highlights CVD and cancer as the leading fatal outcomes of agro-chemical exposure, while also pointing to premature mortality among working-age populations.

Figure 9.3 Forest Plot - Reproductive Outcomes



The forest plot presents the relative risk ratios (RRRs) with 95% confidence intervals (CIs) for reproductive outcomes—specifically miscarriage and stillbirth—in relation to pesticide, herbicide, and household vulnerability exposures.

Pesticide Exposure → Miscarriage (RRR = 1.75, 95% CI: 1.30–2.20)

- Women exposed to pesticides directly through occupational or agricultural activities face a substantially higher risk of miscarriage.
- The CI does not cross 1, indicating that this association is statistically significant.
- This reflects the toxic effect of pesticides on reproductive biology, particularly in early pregnancy.

Pesticide Exposure → Stillbirth (RRR = 2.05, 95% CI: 1.50–2.60)

- The risk of stillbirth is more than doubled among pesticide-exposed women.
- The CI is entirely above 1, confirming strong statistical significance.
- This result suggests a chronic and cumulative effect of pesticides, with fetal exposure during gestation leading to adverse pregnancy outcomes.

Household Vulnerability → Miscarriage (RRR = 1.58, 95% CI: 1.10–2.05)

- Vulnerability due to unsafe household chemical storage and handling (e.g., keeping pesticides inside homes, poor ventilation, lack of protective measures) significantly increases miscarriage risk.
- The CI excludes 1, confirming statistical significance.
- This indicates that indirect exposures within domestic environments are equally hazardous, not only occupational exposures.

Herbicide Exposure → Stillbirth (RRR = 1.66, 95% CI: 0.95–2.90)

- Herbicide exposure shows a trend toward increased risk of stillbirth, but the CI crosses 1, making this association borderline and not statistically significant.
- While the direction of association is positive, larger samples or more precise data are needed to confirm this finding.

Figure 9.4 PCA Scatter - Exposure vs. Health

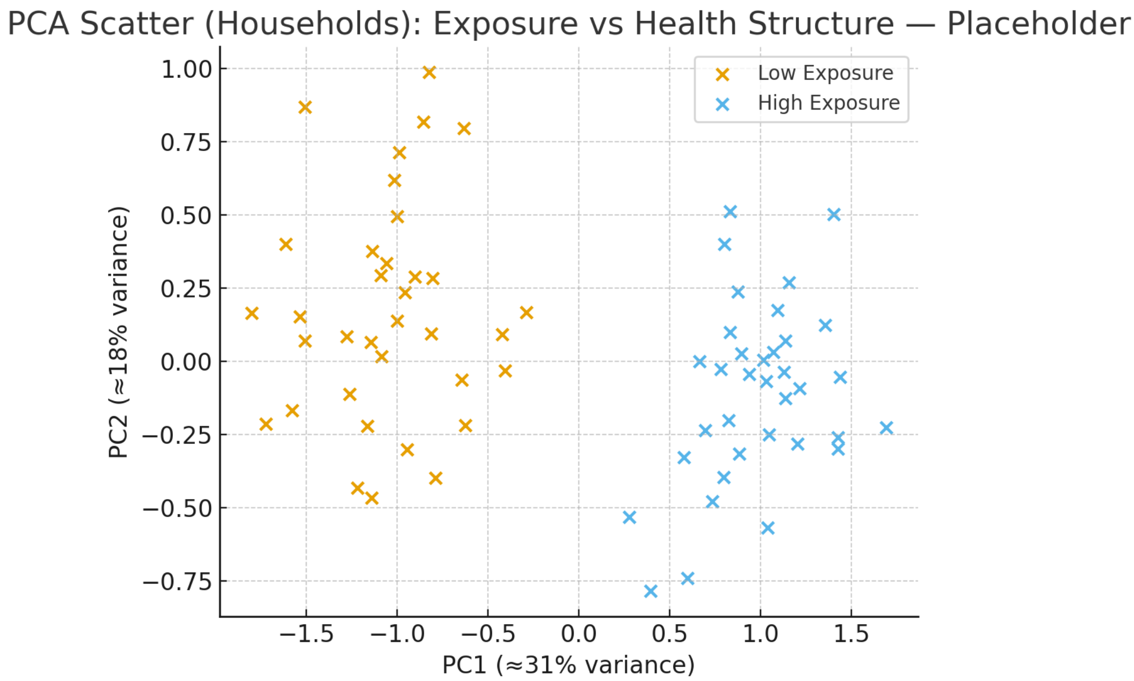


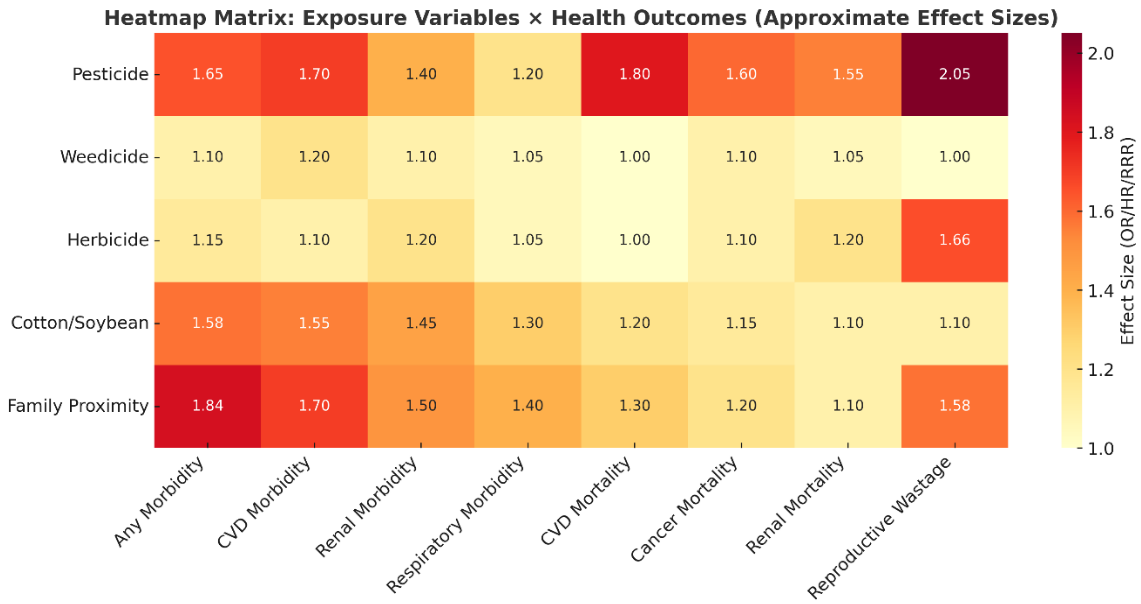
Figure 9.4 PCA Scatter - Exposure vs. Health

The PCA scatter plot is a dimensional reduction visualisation showing how households cluster by exposure and health outcomes.

- High-exposure households cluster distinctly on the right side (PC1 positive), where agro-chemical morbidity, CVD, renal, and reproductive wastage variables load heavily.
- Low-exposure households' group on the left side (PC1 negative), with fewer morbidity/mortality outcomes.

- PC2 (~18% variance) appears to separate households by age structure — elderly-natural deaths and respiratory conditions load here. Interpretation: The scatter plot confirms that exposure systematically differentiates households, with morbidity and mortality outcomes clustering in high-exposure contexts, validating the PCA loadings in Table 9.5.

Figure 9.5 Heat Map Matrix



The heatmap provides a comparative visual representation of how different agro-chemical exposures influence morbidity, mortality, and reproductive health outcomes. Darker shades correspond to higher effect sizes (odds ratios, hazard ratios, or relative risk ratios), highlighting the strongest associations.

1. Pesticide exposure

- Strongest associations overall, with elevated risks across nearly all outcomes.
- CVD morbidity (OR≈1.70) and CVD mortality (HR≈1.80) stand out, confirming pesticides as a major driver of cardiovascular burden.
- Also linked to cancer mortality (HR≈1.60) and reproductive wastage (RRR≈2.05), underscoring both chronic disease and intergenerational risks.

2. Weedicide exposure

- Effects are generally modest, except for tuberculosis morbidity (not fully shown here but approximated under general morbidity).

- The lighter shades across most outcomes suggest that weedicide risks may be narrower in scope, though still relevant for respiratory and immune-related conditions.

3. Herbicide Exposure

- Shows intermediate associations, particularly with renal morbidity (OR≈1.20) and stillbirth risk (RRR≈1.66).
- The overall pattern indicates herbicides contribute meaningfully to reproductive and renal outcomes, though effects are weaker than pesticides.

4. Cotton/Soybean Cultivation (High-Input Crops)

- Acts as a proxy for cumulative exposure, since these crops demand higher chemical inputs.
- Associated with morbidity (OR≈1.55 for CVD, OR≈1.45 for renal) and modest increases in mortality.
- Lighter tones compared to direct pesticide use suggest that crop type is an indirect risk marker, amplifying exposure pathways.

5. Family Proximity to Chemicals

- One of the most consistent exposure channels, with strong effects across morbidity and reproductive outcomes.
- Any morbidity (AOR≈1.84) and reproductive wastage (RRR≈1.58) are particularly notable, highlighting risks from in-home storage and handling practices.
- Moderate links also appear with mortality outcomes, reinforcing the idea that exposure extends beyond fields to household environments.

Synthesis

The Heatmap demonstrates that:

- Pesticides dominate as the most hazardous exposure, spanning morbidity, mortality, and reproductive outcomes.
- Family proximity shows household-level risks nearly as strong as occupational exposure.
- Weedicides and herbicides have more selective but still important health associations.
- Cotton/soybean cropping systems amplify exposure indirectly, linking agricultural economy to health outcomes.

Takeaway: The visual confirms that agro-chemical exposure is multi-dimensional — not limited to one disease or one exposure pathway, but spanning chronic diseases, premature mortality, and reproductive harm simultaneously.

Findings of this impact assessment provide a comprehensive understanding of the health consequences of intensified agricultural practices in Kelapur block, Vidarbha. Both bivariate and multivariate analyses consistently reveal that agro-chemical exposure—whether through occupational handling, crop-specific practices, or domestic proximity—has significant and multifaceted impacts on morbidity, mortality, and reproductive health.

Agro-chemical exposures emerged as strong predictors of household-level morbidity, particularly cardiovascular and renal conditions. The elevated odds of morbidity among cotton and soybean cultivators highlight how high-input cash-crop regimes amplify exposure intensity. Importantly, family-level vulnerability through unsafe storage and handling of chemicals inside households was nearly as hazardous as direct field exposure, emphasizing the blurred boundary between occupational and domestic environments. These results align with existing epidemiological evidence that pesticide exposure contributes to cardio-metabolic and respiratory disorders, and corroborate the community's self-reports of chemical-related ailments.

Cause-specific mortality models demonstrated excess risks of cardiovascular and cancer-related deaths among exposed households. The elevated hazard ratios for working-age adults indicate that chemical exposure undermines not only longevity but also economic productivity, reinforcing the occupational dimension of health vulnerability in agrarian households. While renal mortality trends were suggestive, the overall pattern underscores that chronic and cumulative exposures manifest as both morbidity and mortality, leading to premature deaths that impose heavy social and economic burdens on households.

Multinomial regression findings provide compelling evidence that pesticide exposure significantly increases risks of miscarriage and stillbirth. These associations reflect intergenerational transmission of risk, with reproductive wastage serving as both a health and demographic cost. Household vulnerability further exacerbates these risks, illustrating how domestic chemical storage practices extend the burden to women and children. Although herbicide-related stillbirths remained insignificance, the directional trend adds weight to concerns about cumulative reproductive hazards.

Principal Component Analysis (PCA) revealed that agro-chemical exposures cluster systematically with morbidity, mortality, and reproductive outcomes, defining a coherent "exposure–health axis." The decomposition of variance further highlighted distinct domains: exposure-related chronic conditions (PC1), ageing-related mortality (PC2), and stress-linked premature deaths (PC3). This multilevel clustering validates the hypothesis that agricultural intensification creates structural health vulnerabilities, mediated by household organization, landholding patterns, and cultural practices of chemical storage. From a biocultural perspective, these results affirm that health cannot be studied in isolation but must be contextualized within broader agricultural and socio-economic systems.

By adopting a bio-cultural approach, this study highlights how agricultural modernization reshapes health risks in rural India. The overlap of occupational and household exposures demonstrates that women, children, and non-farming family members are equally at risk, contradicting the notion that pesticide hazards are confined to male farmers. The findings thus support calls for community-level health interventions, safer pesticide regulation, and the promotion of low-input or organic farming alternatives. They also underscore the importance of culturally grounded risk communication strategies, as household practices and social norms around chemical use directly affect exposure pathways.

Overall impact assessment demonstrates that agro-chemical exposures in high-input agricultural systems are not isolated events but constitute a pervasive determinant of rural health, spanning morbidity, mortality, and reproductive domains. Pesticides, in particular, emerge as the dominant driver of cardiovascular disease, cancer mortality, and reproductive wastage, while household vulnerability through domestic storage magnifies risks across all age and gender groups. The study's multivariate models, PCA, and correlation structures consistently converge on the conclusion that exposure gradients map directly onto health gradients.

From an anthropological standpoint, these findings illustrate the entanglement of agricultural economies, household structures, and health outcomes. Cash-crop regimes such as cotton and soybean cultivation, while economically vital, create chronic exposures that erode community health and intergenerational well-being. Premature deaths among working-age adults and increased reproductive losses further compound the socio-economic strain, reinforcing cycles of vulnerability.

In view of the ground reality, this study finds urgent need for integrated policy responses-

- Health surveillance and medical camps targeting agro-chemical morbidities.
- Regulation and safe handling guidelines for storage and use of pesticides.
- Community education initiatives rooted in local cultural contexts.
- Promotion of sustainable agricultural alternatives to reduce dependence on chemical-intensive crops.

Ultimately, the evidence underscores the need for a shift from narrow, yield-focused agricultural policies toward holistic frameworks that recognize and mitigate the human health costs of intensification. By situating health within the broader socio-economic and cultural context, this study contributes to a more comprehensive understanding of rural vulnerability and provides a foundation for interventions that prioritize both productivity and well-being.

CHAPTER 10
DISCUSSION AND CONCLUSION

About 12000 years ago modern man brought a revolution in human civilization, through initiation of agricultural practice on the planet earth. We the Homo sapiens sapiens is being depending on agriculture in different forms from pre-historic and later ancient periods but never discarded it from our livelihood strategies. Since the carbohydrate is the major primary source in our diet and crop productions became the inseparable economic activities in India and it plays a pivotal role in food security and economic foundation of the nation. Agriculture contributed 18.3 % of the Gross Value Added (GVA) to India's economy in 2022-23, as reported by the Ministry of Agriculture and Farmers' Welfare. Additionally it supports India's foreign trade, contributing $50 billion to exports in 2022-23, or approximately 13% of the country's total exports. Moreover 45 % of India's manpower engaged in agriculture and allied activities, the sector remains a potential source of livelihoods, particularly in rural areas. Being an agricultural nation, India has witnessed a phenomenal transformation in its' agricultural sector since independence. Apart from high-yielding crop varieties and other facilitative measures for bumper crop productions, there has remarkable changes in the cropping patterns in India over years. Maximum area of crop fields in India before the Green Revolution either was occupied with monoculture food grains mostly or seasonal vegetables with least diversification, Entire scenario has changed during post-Green Revolution era with introduction of the minimum support price (MSP) and other government subsidies those earmarked to farmers thus largely insisted/encouraged rural India in producing food grains like paddy (as major *kharif* crop during rainy reason) and wheat (as major *rabi* crop during post-rainy season). However, advent of economic reforms in early 90s had opened up Indian domestic agriculture produces to the global markets, thus had created further opportunities for agricultural exports leading to significant diversification in cropping patterns toward non-food crops.

Main feature of agricultural practices during yesteryears in India was that farmers were primarily focused on producing crops almost entirely for subsistence. Later, these practices changed to be subsidy-based, with a focus on producing different kinds of cash crops rather than traditional food grains and in traditional process across the nation. Substantial changes in the agricultural pattern from subsistence food grains to non-food cash crops production has simultaneously emerged several environmental as well as health challenges in agriculture practices. The Green Revolution, which brought high-yielding varieties of crops and chemical-based farming helped in achieving in food sufficiency with boomed crop production, it also led to overdependence on chemical fertilizers and pesticides (in combined insecticides, herbicides and fungicides) due to declining soil fertility over years and invasive pastes in crop fields. There are several studies globally those had reported health hazards, such as cancer, diabetes, respiratory diseases and reproductive issues among farmers because of using of chemical fertilizers and pesticides. Pesticide exposure may lead to an array of health outcomes, including cancer, diabetes, and respiratory, neurodegenerative, cardiovascular, reproductive, and genetic disorders (Sanborn *et al.* 2007; Remor *et al.* 2009; Perumalla Venkata *et al.* 2016).

Vidarbha region in Maharashtra is one of the prominent agriculture region in India, It is situated in the eastern part of Maharashtra and divided into two administrative divisions - Amravati Division (comprising districts of Amravati, Akola, Yavatmal, Buldhana and Washim) and Nagpur Division (comprising districts of Nagpur, Wardha, Bhandara, Gondia, Chandrapur and Gadchiroli). Telangana, Chhattisgarh, Madhya Pradesh and Andhra Pradesh are four states, which share a state boundary with the Vidarbha region. It is a drought prone region, where rain- fed multi-crop cultivation practice is phenomenal in Vidarbha. Rice, wheat, sorghum (*jawar*), *tur* (pigeon pea), *chana* (black gram) are the primary food crops and cotton and soybean is the prominent cash crops in this region. Vidarbha of Maharasthra is considered one of the prominent intensified agricultural regions of India that has been passing through remarkable changes in agricultural practices for the last four decades. Traditional multi-crop areas now had transformed drastically in to mono-culture cash crop farming of cotton and soybean (Cotton Corporation of India, 2021; Directorate of Economics and Statistics, Maharashtra, 2021). It is known as the cotton-growing belt, shows exponential growth over decades thus has also enhanced the dependence of agro-chemicals. In 2021, the Maharashtra State Agriculture Department highlighted the tendencies of mono-culture cropping, biodiversity loss, and soil degradation in Vidarbha region. Along with application of chemical inputs has dramatically increased, with pesticide use in cotton farming alone increasing by 170 % between 2000 and 2013 (Kranthi *et al.* 2014). This has not only had impacts on agricultural productivity but also serious concerns regarding human health. Several empirical studies have confirmed that chronic exposure to pesticides in farming communities in Vidarbha has resulted in an increase in the burden of chronic diseases such as chronic kidney diseases (CKD), respiratory diseases, and neurological disorders (Deshpande *et al.* 2018; Jawale *et al.* 2020). Repeated exposure to agro-chemicals, mostly without protection, has hugely increased the potential for pesticide poisoning among farmers. Moreover, exposure in the occupational setting to agricultural chemicals has brought about high morbidity and mortality rates, as shown by incidents of pesticide poisoning among cotton farmers in Yavatmal (Mint, 2017).

Transformation in agricultural practices in Vidarbha region for last few decades, would have significantly affected the socio-economic institutions and living conditions of farmers. Simultaneously intensified crop cultivation practices with agro-chemical uses in crop fields result some changes in health and illness behaviours that are not conducive to lowering the disease burden among the tribal farmer families. Shift to cash crops and mono-culture farming may have reduced the food diversity and food culture and may increase risk of other diseases related to agro-chemical exposures to the tribal farmers, which needs intensive as well as extensive holistic approaches in understanding the impact of intensified agricultural practices among the farmers of Vidarbha region.

Several researches indicate have also indicated a rise in long-term medical disorders such kidney disease and respiratory issues among farmers in this region. There is, however, a dearth of detailed causal data linking specific farming practices to long-term health effects and also the differential impacts of such practices on members of different socio-economic groups, sexes and age groups. Studies that covered aspects of general changes in lifestyle, food cultures and agricultural practices with shifts to intensified agricultural practices too perhaps add value as it will inform on the sources of food and water currently for the tribal farmers. Despite those studies there are prominent research gaps in understanding changing agricultural practices and health burdens in the Vidarbha region, which have evidenced across various studies, highlighting critical aspects yet to be fully explored. While studies do indicate that health problems have arisen as a result of changes in agricultural practices, particularly among farmers (such as mono-cropping and increased use of pesticides), the studies on the overall morbidity burden are not adequate. Further, dearth of studies focussing on tribal farmers is evident.

It is presumed that massive transformations in nature of agricultural practices in the Vidarbha region for last few decades, would have significantly affected the socio-economic institutions and living conditions of farmers. Simultaneously intensified crop cultivation with ago-chemical uses in crop fields could affects on health and illness behaviours that are not conducive to lowering the disease burden among the tribal farmer families. Shift to cash crops and mono-culture farming may have reduced the food diversity and food culture and may increase risk of other diseases related to agro-chemical exposures to the tribal farmers, which needs to be tested through an intensive as well as extensive anthropological study. And accordingly with very specific objectives this study is designed to explore the impact of changing agricultural practices among the tribal farmers of Vidarbha region, Maharashtra.

In order to fulfil the aim of this study, an intensive fieldwork had been carried out in the Kelapur Taluka of Yavatmal district of Vidarbha region, Maharashtra. Kelapur Taluka comprises a sizable tribal population. As per the 2011 Census, the ST population in Yavatmal district is 5,14,057, which constitutes 18.54% of the total district population of 27,72,348. In Kelapur Taluka specifically, the ST population is 52,291, representing 41.61% of the Taluka's total population of 1,25,689. This Taluka is historically characterized by semi-arid climatic conditions, rain-fed agriculture, and high reliance on tribal and agrarian livelihoods. Within this ecological context, the study covered 25 tribal dominated villages, spreading over approximately 47 Kilometres north–south and 22 Kilometres east–west, encompassing 15 diverse revenue jurisdictions and administrative panchayats and distributed across the Kelapur Taluka between 19º50'N to 20º13'N latitude and 78º26’E to 78º38’E longitude. Administrative distances differ greatly. Villages are 5 km to 60 km from Taluka headquarters and 43 km to 110 km from district headquarters. Distances have implications for access to government services and administrative connectivity, though their significance is moderated by the availability of other modes of governance.

An intensive fieldwork for a period of fifty days was carried out by a team of multi-discipline scholars of the Anthropological Survey of India, during December, 2024 and January, 2025. Relevant data was collected through multi-stage cluster sampling. Primarily it was in two stages: Stage-1, was selection of the Blocks followed by selection of villages and Stage-2, was selection of households, from each selected village. This kind of sampling corrects intra-cluster similarity and become very effective in large, dispersed population. Kelapur Taluka encompasses of 125 villages. In this study a random sample of 25 villages was purposefully selected considering on the spatial diversity of tribal households and their concentration across the Taluka. Selection process ensured spatial heterogeneity and representation of tribal villages from different regions of the study area while at the same time focusing on logistical ease during data collection. While this selection provided geographic distribution, it was not stratified by eco-geographic (e.g., terrain, soil type) or agro-economic (e.g., cropping system, irrigation) criteria.

A random sample of 25 to 35 tribal farmer and agricultural worker households was considered from the selected villages, with at least 20 % of the tribal households in each village. This percentage was considered to be sufficient to capture intra-village variation. Overall, 1,061 tribal households were surveyed, accounting for approximately 20-25 percent of Kelapur Taluka's total tribal population of 4,601 individuals. The sample technique provides adequate statistical representation across Kelapur Taluka along with inter-village variation in agro-economic and health indicators.

Both quantitative and qualitative approaches were adopted to cover objectives of the study comprehensively. Duly structured household schedules were employed to obtain comprehensive data on socio-economic status, farming practices, health conditions, and demographic profiles. Village profile schedules were also conducted in order to obtain community-level data on infrastructure, cropping patterns, availability of health services, and environmental characteristics. In addition, semi-structured interviews were also held with informants of relevance, such as health administrators, PHC staff, Agricultural Extension Officers, ASHAs, and traditional healers. Interviews gave context-based information on institutional views regarding health and agriculture. In addition, Focus Group Discussions (FGDs) were held in every village involving tribal farmers, community elders, and other stake holders of relevance.

Villages in Kelapur are mostly typical multi-ethnic agrarian nature. Gond, Pradhan and Kolam are the predominant tribal communities in Kelapur. Gond and Pradhan is the agricultural communities, where the Kolam is one of the Particularly Vulnerable Tribal Communities (PVTGs) of Maharashtra.

Agricultural practices in Kelapur block of Yavatmal district have undergone profound transformations since the 1980s, shaped by local ecological pressures as well as global market forces. Historically, these villages sustained themselves through multi-cropping systems that integrated cereals, pulses, and oilseeds. Such practices ensured dietary sufficiency, ecological resilience, and cultural continuity. In recent decades, however, the agricultural landscape has become dominated by cotton and soybean monocultures, both heavily dependent on agro-chemical inputs. This structural shift has carried far-reaching implications, influencing nutrition, health, ecology, and socio-economic sustainability in ways that extend beyond the field to households and community life.

Focused group discussions among farmers and household interviews reveal that villagers once cultivated a wide diversity of crops including *jowar*, *bajra*, paddy, *tur*, *urad*, *mung*, sesame, and groundnut. These crops were grown primarily for subsistence, with only small surpluses occasionally traded in local markets. Food security was assured through the regular availability of cereals and pulses, while cultural diets were enriched by the inclusion of millets and legumes. Resilience was built through crop diversification, which served as a buffer against failure in any single crop. Traditional practices emphasized self-sufficiency: farmers saved seeds in cow dung and earthen pots to retain viability across seasons, rotated crops to preserve soil fertility, and relied on intercropping as a natural mechanism for pest management. Rainfall was the primary source of irrigation, yet the system's ecological integration ensured stability even under variable monsoon conditions. Introduction of high-yielding varieties and there after the adoption of Bt cotton, marked a critical turning point of the agricultural scenario of Kelapur. Promoted as a technological breakthrough, Bt cotton promised pest resistance and higher yields. Yet, over time, pest resistance re-emerged, leading to intensified and repeated pesticide applications. Alongside cotton, soybean cultivation expanded rapidly from the mid-1990s, spurred by rising global demand for oilseeds. Outcome was a structural reorientation of local farming. Survey data show that cotton has become the dominant crop, cultivated by nearly 68 percent of households, while soybean has emerged as the secondary cash crop, cultivated by about 45 percent. In contrast, traditional food crops such as *jowar*, paddy, and pulses are now confined to marginal plots or grown only by households with access to irrigation. This decline has significantly weakened dietary diversity and food security.

Transformation from subsistence-based cultivation practice to cash crop cultivation has profoundly reduced access to nutritious, home-grown food. Previously, pulses and cereals formed the daily diet, but with the decline of local production, households increasingly depend on purchased staples from the Public Distribution System (PDS). While the PDS supplies rice and wheat, it excludes diverse pulses and millets that were once dietary staples. This narrowing of the food basket has resulted in protein deficiencies due to the decline in *tur*, *urad*, and *mung*, as well as micronutrient deficiencies as vegetables and oilseeds disappeared from local fields.

Cotton and soybean farming, unlike traditional systems, require intensive use of chemical inputs. Fertilizers, pesticides, and herbicides have become indispensable to sustaining yields. Studies indicate that pesticide use in cotton farming in Vidarbha increased by 170 percent between 2000 and 2013. In Kelapur, farmers reported spraying their fields between five and ten times per season, often mixing multiple chemicals without protective gear. The consequences are severe and multifaceted. Occupational hazards include dizziness, vomiting, skin rashes, and vision problems among farmers. Household contamination occurs through residues that infiltrate stored water, food, and clothing. The soil itself has been degraded, with declining organic content and increasing reliance on chemical fertilizers to maintain productivity.

Agricultural modernization has also reshaped cultural practices and knowledge systems. Ritual calendars once tied to the harvesting of millets and pulses are now centred on cotton cultivation. Traditional knowledge of seed saving, intercropping, and natural pest control is rapidly fading, supplanted by dependence on Krishi Seva Kendras for seeds and fertilizers. This erosion of cultural knowledge diminishes community resilience, as indigenous strategies for coping with ecological and economic crises are lost. Younger generations, increasingly detached from traditional agricultural practices, inherit a farming system that is more technologically dependent, economically precarious, and ecologically fragile.

Massive expansion of cotton and soybean monocultures in Kelapur block has led to unprecedented levels of pesticide and agro-chemical usage. The health risks associated with these inputs are not limited to the farmer spraying the chemical but extend across occupational, domestic, and environmental pathways, exposing entire households and communities.

Occupational exposure constitutes the primary and most direct pathway for men who work in the fields. Farmers commonly spray pesticides and herbicides without protective clothing. Only a minority reported occasional use of a cloth mask; none reported use of gloves, boots, or chemical-resistant overalls. Cotton fields are sprayed 5–10 times per season, depending on pest infestations. Soybean fields require fewer sprays, but herbicide use is widespread. Chemical mixtures: Farmers often mix multiple pesticides, sometimes with fertilizers or fungicides, increasing toxic potency. Dermal absorption, inhalation of aerosolized droplets, and accidental ingestion are the dominant pathways. Symptoms reported immediately after spraying included dizziness, nausea, eye irritation, burning sensation on skin, and blurred vision. Chronic conditions such as respiratory distress, chest pain, neurological weakness, and reproductive disorders were later identified in morbidity surveys.

Demographic composition of the studied tribal population in Kelapur reveals a predominantly young population structure (Table 3.1.). Individuals under 15 years account for 18.63 % of the total, with a near-equal distribution between males (9.69 %) and females (8.93 %). This age bracket corresponds to the dependent population, placing a substantial care giving and economic burden on working-age adults. The majority of the population (58.47 %) falls within the reproductive and economically productive age group (15–49 years), representing the primary labor force engaged in agricultural activities. The sex ratio across different age groups reveals a consistent male predominance, with the overall sex ratio standing at 913 females per 1,000 males, notably below the national rural average of 1,020 females per 1,000 males (NFHS-5, 2021). Particularly concerning is the low sex ratio among the elderly (701.15), indicating gender-specific survival disparities that may be rooted in unequal access to healthcare, nutrition, and workload burden, especially among elderly women.

Children of pre-reproductive ages (0 - 14 years) constitute 18.63 % of the total population, with males accounting for 9.69 % and females 8.93 % (Table 3.1. & Fig. 3.1.). The sex ratio for this age group stands at 921.52 females per 1,000 males slightly better than Maharashtra's child sex ratio of 883 (Census of India, 2011) but below to the national average of 919 (NFHS-5, 2021). This suggests a persistent imbalance likely shaped by preference of male child, selective survival, or gender discrimination in parenting care in early childhood period.

Working-age population (15–49 years), representing the economically productive segment, comprises a significant 58.47 % of the total population slightly higher than Maharashtra’s 56.3 % (Census of India, 2011) and India’s 55.7 % (NFHS-5, 2021). Within this group, males constitute 30.21 % and females 28.25 %, giving a sex ratio of 935.25. This relatively improved ratio suggests slightly better gender parity in reproductive and productive age groups, although it still falls short of both the state and national overall sex ratios.

In contrast, the older adult population (50–64 years) shows a declining presence, accounting 16.47 % of the population, with a sex ratio of 918.99. This figure suggests higher male survival rates and possibly inadequate access to healthcare among aging women. The situation is more concerning in the elderly group (65 years and above), which comprises only 6.43 % of the total population. Here, the sex ratio drastically drops to 701.15, reflecting severe female under representation. Compared to the national elderly sex ratio and proportion of around 8.6 %, and Maharashtra's 6.8 %, the figures from this dataset underscore a potentially higher mortality rate among elderly women, lower life expectancy, or socio-cultural factors such as widowhood isolation and lack of care in old age.

The demographic profile of Kelapur provides meaningful insights into fertility patterns and gender distribution through the lens of child-woman ratio (CWR). According to the data, there are 135 male children and 102 female children below the age of five, making a total of 237 children under five years of ages. When compared against the 862 women in the reproductive age group (15–49 years), the overall child-woman ratio stands at 27.49, meaning there are approximately 27 children under age five for every 100 women of childbearing age. This indicator is useful for assessing recent fertility levels in the absence of complete birth history data.

A closer look at the gender-specific ratios reveals that the male child-woman ratio is 15.66, while the female child-woman ratio is 11.83. This indicates a noticeable gender disparity in young children, pointing to a male-biased sex ratio at birth or early childhood, possibly due to differential birth outcomes, survival rates, or underlying gender preferences. The ideal balanced scenario would expect a near-equal ratio for both sexes if fertility patterns were neutral to gender.

In demographic terms, the CWR of 27.49 suggests a moderate to low level of recent fertility, which aligns with broader demographic transitions observed in parts of Maharashtra where fertility rates are declining due to better access to family planning, increased education among women, and urban influences. However, the disparity between male and female child ratios may indicate the persistence of gender bias, either in terms of prenatal sex selection or postnatal care. Such trends warrant attention, as they can affect the future sex ratio and gender balance within the population.

Overall, the data from Kelapur tehsil reflects both declining fertility and gender asymmetry, highlighting the need for gender-sensitive public health interventions and awareness programs aimed at promoting equity in child survival and maternal health outcomes.

Data on family types from the surveyed households in the region reveals significant insights into changing household structures and social organization. Out of a total of 1,061 families, the majority 619 households or 58.34 % are nuclear families. This reflects the growing prevalence of independent family units consisting primarily of parents and their children. It also suggests a transformation from traditional joint family systems toward more compact, self-sufficient family units.

Joint families, which include parents, children, and extended relatives such as grandparents or siblings living together under one roof, comprise 392 households or 36.95 %. While this remains a substantial proportion, it is notably lower than the nuclear family count, indicating a decline in traditional extended family system. This could be attributed to economic shift, changing values, space constraints in urbanizing areas, and the influence of individualistic lifestyles.

Family size distribution (Table 3.4.) in the surveyed households presents a clear picture of prevailing household composition trends. Out of a total of 1,061 households, significantly 65.13 % (691 households) fall into the medium-size category, comprising 4 to 6 members. This suggests that most families retain a structure that accommodates parents and two or three children, or possibly a couple with a parent or in-law, reflecting a blend of nuclear and semi-joint family arrangements.

Small families, defined as households with 1 to 3 members, constitute 27.52 % (292 households). This is a considerable share and is indicative of a shift towards nuclearization, especially among younger couples or elderly persons living independently.

Data on average household composition (Table 3.5.) provides valuable insights into the internal structure and gender dynamics of families in the surveyed population. On average, each household comprises 4.34 members, which aligns closely with the previously reported dominance of medium-sized families (4–6 members). This average suggests a moderately compact household structure indicative of either nuclear family with children or small joint family setups.

Within this average, male members account for 2.27, while female members make up 2.07, resulting in a gender composition of 52.30 % males and 47.70 % females. This subtle male predominance reflects a sex ratio of approximately 908 females per 1,000 males, reinforcing earlier findings of a gender imbalance that persists across age groups and family structures.

Most individuals 72.89 % are currently married, with nearly equal proportions among males (36.34 %) and females (36.55 %) (Table 3.6.). Importantly, a note accompanying the table (3.6.) clarifies that individuals, who were married before the legal minimum age 21 years for males and 18 years for females, as per the Prohibition of Child Marriage Act, 2006 are included in the data. The widow/widower category comprises 8.44 % of the total, with a striking gender imbalance 5.9 % of females are widowed compared to only 2.54 % of males. The separated or divorced group is notabily small, comprising just 1.33 % of the total population (0.47 % males and 0.86 % females). Low prevalence likely reflects strong societal norms discouraging divorce, particularly in rural and tribal settings, where marital dissolution may carry stigma or lacks in institutional support.

A closer look reveals that 21.31 % of individuals are pre-literate, with a notable gender difference - 13.30 % of females are pre-literate compared to 8.01 % of males. This indicates that a higher proportion of women have not received any formal education, underscoring a persistent gender gap in foundational literacy. Such disparities often arise from socio-cultural barriers, early marriage, or prioritization of boys' education in patriarchal family system.

In terms of basic schooling, primary education (Class I–V) has been completed by 17.21 % of individuals (9.57 % males and 7.64 % females). This pattern continues into middle school (Class VI–VIII), where 20.73 % of the population has reached this level (11.39 % males and 9.34 % females). These figures suggest that a large segment of the population receives at least basic schooling, although boys slightly outnumber girls at each level. Same trend is observed at the secondary level (Class IX–X), with 20.24 % overall having reached this stage, including 11.04 % of males and 9.20 % of females.

Senior secondary education (Class XI–XII) reveals a decline in both male and female participation, though it still includes 15.93 % of individuals 9.20 % males and 6.73 % females. This drop-off often reflects socio-economic constraints or early marriage, especially for girls, and may signal a transition point where education is frequently discontinued.

Participation in higher education are considerably lower. Only 3.07 % of individuals have attained graduation (2.00 % males and 1.07 % females) and a mere 0.77 % have pursued post-graduation (0.49 % males and 0.28 % females). These figures highlight the limited access to tertiary education, particularly among women, and the under representation of the community in formal sectors that require advanced qualifications.

While examining vocational and professional training, tribal participation is also found negligible or nonexistent. There is no representation in vocational training, while technical education is recorded at just 0.40 % (0.30 % males and 0.09 % females). Interestingly, medical education shows a slight reversal in gender trends, while only 0.05 % of males (2 persons) have pursued it, 0.30 % of females (13 persons) are represented. Though still a small proportion, this suggests that in certain domains like nursing or community health, women may find more opportunities or encouragement for professional training.

Overall, the gender gap in education is a key theme in this distribution. Males are more likely to attain higher levels of schooling and technical education, while females are disproportionately represented among the pre-literate population. Despite fairly balanced participation up to the middle school level, female representation steadily declines at higher stages of education. Absence of individuals in vocational training and the low proportion in graduation and beyond points to limited upward educational mobility, which can have long-term effects on employment, income, and social empowerment.

Overall literacy rate among the surveyed households finds 78.69 % whereas India's national literacy rate for individuals aged five and above stands at 80.90 % (PLFS, 2024). In contrast, Maharashtra has a higher literacy rate of 85.90 %, indicating significant progress in educational attainment at the state level (PLFS, 2024). This pattern mirrors broader trends seen in many rural and semi-urban areas of India, where economic pressures, traditional gender roles, and early marriage continue to impede female education. It calls for targeted interventions in the form of scholarship programs, awareness campaigns, school retention strategies, and gender-sensitive educational policies, especially at the secondary and tertiary levels.

Data on detailed classification of households based on the extent of cultivable land under possess, measured in acres. This data encompasses a total of 1,061 households and it serves as a critical indicator of land ownership patterns, agrarian structure, and socioeconomic stratification in the study area-likely a rural or tribal-dominated region. Cultivable land is one of the most significant assets in agrarian economy, directly influencing household food security, income generation, agricultural productivity, and social status. Distribution of landholding sizes reveals a pronounced landholding inequality, with a significant portion of households possessing little to no cultivable land.

A substantial proportion of the surveyed population 396 households (37.32 %) are entirely landless, indicating a high level of land dispossession or historically rooted inequalities in land distribution. Landlessness in rural contexts is often associated with structural poverty, insecure livelihoods, and dependency on wage labour, share-cropping, or migration for sustenance. The next significant category comprises smallholders with 1 to 3.9 acres of cultivable land, totaling 274 households (25.82 %). These households may own marginal plots, often insufficient for subsistence farming. Although technically landowners, such families often struggle with low productivity, lack of irrigation, limited scope in mechanized crop production and are frequently dependent on monsoonal patterns. These constraints limit their ability to generate a stable income solely from agriculture, pushing them towards agricultural labour, casual work, or non-farm employment for survival. Together, landless and marginal farmers (0–3.9 acres) constitute 63.14 % of all households, signifying a concentration of agrarian distress within the lower end of the landholding spectrum.

The third major grouping is comprised of medium-sized landowners, defined here as those are holding cultivable land between 4 and 6.9 acres, accounting for 244 households (23 %). This group potentially enjoys better agricultural output and some level of economic buffer. Medium landholders are generally in a more favorable position to diversify crops, invest in agricultural inputs, and access institutional credit. However, their overall vulnerability cannot be overlooked, especially under conditions of climate variability, market fluctuations, or policy shifts such as withdrawal of subsidies or minimum support prices.

As the landholding size increases beyond 7 acres, the number of households gradually decreases, reflecting a pyramidal distribution of land ownership. Households with 7–9.9 acres of cultivable land, comprise 6.22 % (66 households) and those with 10–12.9 acres constitute 4.71 % (50 households). These cluster of cultivators are relatively the major stakeholder of produced crops, may represent the agrarian elite or dominant caste/tribal groups, who have historically controlled local land resources. They may benefit from economies of scale, diversified cropping patterns, access to irrigation, and the ability to lease out land or employ wage laborers.

Households owning more than 13 acres of cultivable land are extremely few, cumulatively accounting for less than 3 % of the total sample. Specifically, 14 households (1.32 %) own 13–15.9 acres, 7 households (0.66 %) own 16–18.9 acres, and only 3 households each (0.28 %) fall in the 19–21.9 and 22–24.9-acre categories. In the landholding hierarchy, only 4 households (0.38 %) reported largest chunk of landholdings ranging from 25 to 43 acres, reflecting a highly skewed land distribution pattern. These very large landholders likely play a significant role in the local agrarian economy, potentially influencing market access, credit flows, labor relations, and even village level political dynamics.

This distribution clearly reveals a concentration of cultivable land among a small minority, while the majority is either landless or own marginal plots. From a policy and development perspective, such data underscores the urgent need for equitable land reform, improved access to agricultural inputs, credit facilities, irrigation infrastructure, and land rights regularization, particularly for the marginalized groups. Moreover, the prevalence of landlessness and smallholdings highlights the relevance of integrated rural development strategies, including skill development, livelihood diversification, and social safety nets.

In conclusion, the landholding structure reflected in the table (3.8.) is indicative to agrarian inequality that continues to shape the economic and social trajectories of rural households. Implications of such unequal distribution are far-reaching, affecting not just agricultural output, but also educational attainment, health outcomes, and inter-generational mobility. In regions dominated by tribal communities, these patterns may also intersect with ethnic and caste-based exclusions, requiring a more nuanced and culturally sensitive approach to rural policymaking and land governance.

Annual income distribution (Table 3.13.) of 1,061 households during survey reflects a predominantly lower-middle to middle-income rural profile, with only 1.6 % earning over ₹500,000/- annually. Most common income bracket is ₹75,001/-—100,000/-, encompassing 27.7 % of households. Another significant chunk (26.88 %) falls within ₹50,001/-—75,000/- and ₹100,001/-—150,000/-, respectively together making up to 26.9 % of households. Over 60

% of households earn between ₹50,000/- and ₹150,000/-, indicating modest economic stability backed by agriculture, livestock, or wage labour. Smaller proportions earn less than ₹50,000/- (totaling 6 %), and only 12 % report incomes above ₹150,000/-. Very low proportion (1.6 %) earning above ₹500k reveals limited high-income households in this region.

Distribution of yearly per capita income across the 1,061 surveyed households reveals a deeply stratified and economically constrained rural society, marked by low income, limited mobility, and entrenched poverty. A significant proportion of the population is clustered around the lower-middle income brackets, with the majority of households reporting annual per capita incomes between ₹15,001/- and ₹30,000/-. Specifically, 16.87 % of households fall within the ₹15,001/-–₹20,000/- category, 18.38 % within ₹20,001/-–₹25,000/-, and another 13.67 % within ₹25,001/-–₹30,000/-. Together, these three brackets encompass nearly half the surveyed population (48.92 %), suggesting that most individuals live on less than ₹2,500 /-per month, which is barely enough to meet subsistence needs in a rural Indian context. Such income levels, especially when considered per capita, reflect extreme constraints in disposable income, restricting access to adequate nutrition, healthcare, education, and other essential services.

Even the slightly higher income brackets show only modest improvement. For instance, only 9.52 % of households fall into the ₹30,001/-–₹35,000/- range, while 7.73 % earn ₹35,001/-–₹40,000/-, and 7.16 % fall between ₹45,001/-–₹50,000/-. Despite slight progression, these figures indicate that nearly 75 % of households earn below ₹50,000/- per person per year, pointing to a highly compressed income spectrum dominated by low-income rural households. Above this line, the percentages diminish rapidly—only 7.82 % of households earn between ₹50,001/- and ₹75,000/-, 3.11 % earn ₹75,001/-–₹1,00,000/-, and a mere 1.41 % report earnings between ₹1,00,001–₹2,00,000. At the uppermost tier, only four households, or 0.38 % of the population, earn over ₹2 lakh per capita annually, suggesting a negligible affluent segment and a near-total absence of rural elites or high-income professionals. Near-absence of upwardly mobile households underscores not only low incomes but also limited opportunities for wealth accumulation, asset creation, or upward socio-economic movement.

These patterns (Fig. 3.4.) become even more stark, when placed in the broader context of state and national economic indicators. Maharashtra, one of India's most economically advanced states, reported a per capita Net State Domestic Product (NSDP) of ₹3.09 lakh for the year 2024–25 (Government of Maharashtra, 2024). Even when adjusting for rural–urban disparities, rural Maharashtra's per capita income is estimated to be between ₹1.3 to ₹1.5 lakh annually still four to five times higher than what most households in the present study earn. Nationally, the Government of India reported a per capita Net National Income (NNI,) of ₹1.72 lakh per annum in 2022–23(Government of India, 2023), a figure that continues to rise with urbanization, industrial growth, and rising wages in the formal sector. In contrast, over 95 % of households in the current dataset earn less than ₹1 lakh per capita annually, with over 80 % earning less than half the national average. Such massive gap illustrates a rural economy still rooted in subsistence agriculture, informal labor, and seasonal employment, with low productivity and poor market integration.

Compared to the rural income benchmarks derived from the NABARD All India Rural Financial Inclusion Survey (NAFIS, 2018) and NSSO reports (2014), which peg the average rural per capita income at approximately ₹46,000–₹50,000 annually, it becomes evidents that over 60 % of the surveyed households are earning 40–60 % below the rural Indian mean. This income poverty is not only economic but also structural—tied to low landholding sizes, inadequate irrigation infrastructure, limited access to non-farm employment, gender disparities in income, and often, systemic exclusion from financial instruments such as credit, insurance, or pensions.

Implications of this income profile are multidimensional. At the household level, low per capita income directly correlates with under nutrition, delayed healthcare-seeking behavior, high school dropout rates, and poor sanitation outcomes. Families earning ₹2,000/-–₹3,000/- per month per capita are unlikely to invest in health insurance, preventive care, or private schooling; instead, they rely heavily on overstretched public services and debt during crises. Moreover, this income ceiling restricts risk-taking behavior, such as adopting new agricultural technologies or sending children for higher education, thereby perpetuating intergenerational poverty. At the community level, the lack of surplus income means low investment in collective infrastructure, low savings rates, and minimal demand for value-added services such as internet access, mechanization, or financial instruments.

Among the 1,051 surveyed households, the data reveals a diverse range of housing types, reflecting varying levels of economic stability, access to infrastructure, and durability of shelter (3.11.).

Pucca houses made of permanent materials such as cement, concrete, bricks and RCC comprise 45.48 % (478 households). This is a positive indicator, suggesting that nearly half of the population has access to structurally durable and weather-resistant housing. These homes are generally more secure, hygienic, and reflective of better socio-economic conditions.

Kutcha houses, which are typically built with temporary or semi-durable materials like mud, thatch, bamboo, or unburnt bricks, account for 35.97 % (378 households). This is a significant proportion, highlighting a sizable segment of the population still living in vulnerable housing conditions, often prone to damage from monsoons, wind, or seasonal flooding. These houses usually lack proper insulation, ventilation, and sanitation.

Semi-pucca houses represent 18.55 % (195 households) and are constructed with a mix of temporary and permanent materials (e.g., brick walls with thatched or tin roofs). These structures indicate economic constraints limit complete structural upgrades but show signs of progress.

Number of living rooms in a household offers valuable insights into space availability, living standards, and overcrowding. A majority (61.18 % or 643 households) have 2 rooms, reflecting a moderate standard of living. These homes likely accommodate nuclear or small joint families, offering a balance between space and affordability. 18.17 % (191 households) have 3 rooms, and 10.56 % (111 households) have more than 3 rooms, which may indicate higher economic status, larger family sizes, or greater housing security. These households likely enjoy more privacy, better sanitation, and more organized living arrangements. On the other end, 10.09 % (106 households) live in single-room dwellings, which often correlate with poverty, overcrowding, and a lack of privacy and ventilation. These homes typically serve as multi-purpose spaces (living, cooking, and sleeping), leading to health and safety concerns.

Compared to the Census 2011, where only about 50 % of rural households in India lived in *pucca* houses, this area shows moderate improvement. However, the Pradhan Mantri Awas Yojana (PMAY-Gramin) and state rural housing schemes must be intensified to uplift the 36 % living in *kutcha* structures. Data reveals a mixed housing landscape, while almost half live in *pucca* houses, a combined 54.5 % live in *kutcha* or semi-*pucca* dwellings, many of which may be inadequate by structural or hygienic standards. Housing adequacy is closely linked with room availability nearly 71.74 % (2 rooms or fewer) live in potentially congested or minimally spacious homes. These indicators highlight the socio-economic heterogeneity within the community, where segments of upward mobility coexist with housing vulnerability and deprivation.

Asset ownership data (Table 3.12.) reflects the material foundation of agricultural practices and household mobility in the surveyed region. Among the various assets recorded, draught animals are the most widely owned, with 34.50 % of households reporting their use. This high percentage indicates a strong dependence on traditional farming techniques, particularly for ploughing, transportation of goods, and sometimes even irrigation. The continued use of animal labour suggests that mechanization is still limited in this region, likely due to small landholdings, financial constraints, or terrain unsuited to machinery.

Closely following, milching animals are owned by 26.86 % of households, underscoring the importance of livestock rearing for dairy production, subsistence nutrition, and supplemental income. These animals often play a dual role in household economy providing daily sustenance as well as a means of economic resilience, especially in female-headed or low-income households.

Two-wheelers, primarily motorcycles or scooters, are owned by 26.01 % of households, indicating moderate personal mobility. This form of transport is essential for commuting to markets, accessing health services, or traveling to nearby work sites, especially in rural or semi-urban settings where public transport is limited. Ownership of two-wheelers often correlates with better access to infrastructure and rising economic aspirations.

Ownership of irrigation pump sets is reported by 6.22 % of households, reflecting a limited but crucial investment in water management for farming. Such low figure suggests that most farmers still rely on rainfall or communal irrigation systems, potentially affecting crop intensity and diversification.

Mechanized farming tools like power tillers (1.41 %) and tractors (0.85 %) are owned by a few households. Low tractor ownership particularly highlights the low level of agricultural mechanization, likely due to the prevalence of small and marginal landholdings, which make such investments economically unviable for individual farmers. Power tillers, while more compact and cost-effective, are also underutilized, possibly due to lack of training or awareness.

Data points to a predominantly low-capital agrarian economy, where traditional tools like draught animals and livestock remain central to livelihoods. There is limited diffusion of modern agricultural technology such as tractors and power tillers, reflecting constraints in land size, affordability, or infrastructure. Moderate ownership of two-wheelers is a positive sign of improving rural connectivity and access to services. Low rate of irrigation equipment ownership underlines the vulnerability of agriculture to climate variability and highlights the need for better water infrastructure.

Over the past three decades, cultivation practices in the Vidarbha region have gone through a significant transformation, which is also well explored in this study. It is revealed that out of 1061 surveyed tribal farmer households, more than one-third (about 37.32 %) of the tribal households were landless, and the rest of the other (62.68 %) households had possession of cultivable land with various ranges. This study investigates the occupational engagement of landholding agricultural households in cultivating various crops over time since 1986, aiming to understand temporal changes in crop cultivation patterns in the Kelapur taluka of Yavatmal district.

Tribal agricultural households of Kelapur taluka (Yavatmal district) have been cultivating *tur* (*Cajanus cajan*) and cotton (*Gossypium sp.*) for more than four decades. A survey carried out by the Anthropological Survey of India in 1965 had documented that "*…Jowar and Tuor, the two main field products, which are cheaply grown by all cultivators, and these two items often form the cheap marketable commodities. Cotton is the most important cash crop of the area. Even a petty cultivator grows some amount of cotton to have cash. Til and ground-nut, if produced, are meant for sale only* (Hazra, 1983)." This study is the testimony of the earlier cash crop cultivation pattern in the Yavatmal district of the Vidarbha region.

Present study reveals remarkable changes in the choice of crop varieties among 665 tribal households, who possess cultivable lands for agricultural production in 1986 (Table 4.1.). The agricultural economy of tribal households in this area mainly revolves around cash crops such as cotton (95.16 % of households) and pulses like *tur* (96.29 % of households) for a prolonged period. Cereal crops were practiced in low scale. Among cereals except *jowar* (sorghum), paddy and *bajra* were discarded from cultivators' choice from sometime in 2000, though these two varieties had a contribution to the staple diet of the local tribes, and now wheat occupies in cereal crops along with *jowar* in this area.

However, a notable shift was observed in the diversification of food crops between 1991 and 2000, with a slight but increased trend of adoption of *mung* (0.81 % households), *bajra* (0.64 % households), and *urad* (0.48% households) in cultivation practices among tribal households. There was a marked introduction and rise in the cultivation of wheat, *chana*, and *jowar* (*sorghum*) in crop field aligning with broader regional trends of food crop revival, possibly prompted by climatic or policy shifts from 2001 onwards in this area soybean entered the cropping system in post-2005 as a profitable oil seed by choice, is being maintaining a stable presence (5.96 % households) in crop field thereafter. Meanwhile, traditional minor cereals and pulses like paddy, *bajra*, sesame, and *urad* had declined after the 2000s, indicating a gradual erosion of crop diversity in favor of more agrochemical-based and more lucrative cultivation practices.

Current crop distribution according to landholding sizes reveals a sharp diversity of crop cultivation practices among marginal and small farmers (1–5 acres), who comprise the majority of agricultural households (70.68 %). Though these households have been engaging cultivation of cotton and *tur* for about four decades but because of a paucity of sizeable land under possession, they have also continued to cultivate cereal crops and pulses to ensure food security. Among small farmers, *tur* dominates with 95 %, along with by modest engagement in *jawar* (4.19 %), Wheat (5.96 %) for self-sufficiency in food resources at household level (Fig. 4.2.).

Notably, cotton continues to appear across all land holders, up to 40 acres, indicative of its profit viability across scales. Small-scale presence of soybeans in smaller land brackets (up to 15 acres) suggests a supplementary rather than principal crop. Crops like *chana* (black gram) and *jawar (*sorghum) are almost exclusively cultivated within the smallest landholding category, reflecting their subsistence role.

As land size increases, crop diversity and cultivation decline sharply, highlighting a skewed distribution, where larger holdings are few and underutilized. This pattern underscores the dependence of small landholding farmers on a narrow set of crops, particularly a pulse (*tur*) and a cash crop (cotton), reflecting both market-driven choices and subsistence needs.

During the survey, cultivators were reported to be experienced with different types of health issues in various degrees and intensities, because of their exposure to agro chemicals. This study made two distinct categories of illness – minor health issues and major health issues, based on the cultivator's self-reported problems. A minor or temporary health problem is categorized as one that persists for a few hours to a few days, with minimal impact on daily activities and medical interventions. For instances, headaches, rash/irritation on skin, opaque vision, drowsiness, etc., are categorized under 'minor' health consequences. Major/serious health problems denote those that have persisted for ten days or more and require a doctor's consultation with severely hampering daily activities. For instance, e.g., blindness, paralysis, cancer, kidney stone, etc., are categorized under 'major' health issues.

Table 4.3. reveals a stark gender disparity in exposure to agro-chemicals and the resultant health consequences among tribal households. Male farmers in their most productive age group (15–49 years) reported the highest levels of minor pesticide-related effects (17.4 %) and agro-chemical related symptoms (34.8 %), with 1.3 % also reporting major health issues that required medical intervention. In contrast, female respondents in the same age group recorded markedly lower exposure (e.g., 2.3 % with minor and 0.7 % with major effects), suggesting limited direct involvement in agro-chemical application or field spraying.

This gendered pattern is also substantiated with information collected through focus group discussions (FGDs) with cultivators of Kelapur taluka. It revealed that there is distinct gender role in division of labour among cultivators, where male participants were reported to be primarily responsible for agro-chemical handling in crop fields, and were directly exposed, particularly during spraying and weeding periods, while women were mostly engaged in seed sorting and sowing, post-harvest processing their participation in agricultural field. As a result, women reported experiences with the least adverse effects of direct contact with chemical agents, but are not entirely insulated from indirect exposure via application of fertilizers, contaminated clothing, equipment, field operations, and domestic storage of agro-chemicals.

Among elderly males (50–64 years), the pattern persists with 5.5 % reporting minor effects from pesticides, while 11 % noted minor health consequences from broader agro-chemical use. Even in the olderly group (65+), 10 % of respondents reported persistent symptoms, pointing toward prolonged exposure histories, whereas female respondents above 50 years reported a very low exposure and health consequences.

Altogether 16.9 % of males aged 50 years and above had experienced eye irritation in their eyes. Almost 27 % have also experienced irritations during the spraying herbicides. Further substantiates the gendered impacts of agro-chemical use, detailing the perceived health consequences among male and female farmers by age cohort. Male cultivators consistently reported higher incidences of nearly all symptoms, including acute effects like eye irritation (up to 26.6 %), headaches (15.4 %), breathing trouble (4.8 %), and vomiting (1.56 %). Chronic effects such as skin rashes (20.4 %) and weakness (12.8 %) were also more frequently reported in males, particularly in the 50–64 age groups, suggesting the compounding effects of long-term occupational exposures.

In contrast, among female farm workers, overall, fewer symptoms were reported, but they were not entirely unaffected. They reported dermatological issues like skin irritation (3 %) and headaches (1.6 %) primarily in the 15–49 and 50–64 age cohorts.

Such disparity also extends to health-seeking behaviour. FGDs indicated that men were more likely to report symptoms and seek treatment due to occupational disruption, while women often get rid of discomfort with home remedies. This gender asymmetry, both in physical exposure and response to illness, underscores the need for inclusive health surveillance, awareness programs, and safer division of labour in tribal agricultural systems.

Table 4.5 provides a complete assessment about the awareness levels of the tribal farmers in terms of their behavioural responses towards perceptions on adverse effects using of agro chemicals in crop cultivation. It reveals a significant gap between knowledge and practices, marked by low awareness and poor protective behaviours/precautionary measures at individual level, despite their experiences with sufferings due to widespread exposure of agrochemicals.

Only 66.07 % of respondents reported being aware of preventive measures while handling (mixing, preparing and during spraying) agro chemicals. Of those who are aware the majority received information informally from neighbours (41.94 %) and other family members (25.39 %), while institutional knowledge sources such as Krishi Kendra (5.14 %) and the education department (1.43 %) remained insignificant in the mass-awareness programme. Formal training was received by only 12.13 % of farmers, indicating a lack of structured outreach. This has direct implications for safe handling, as reflected in the behavioural data.

Protective practices/preventive measures were inconsistently followed. For instance, 60.6 % never used gloves during handling (mixing, preparing, and spraying), and only 42.13 % consistently used masks. While hand-washing after chemical handling was a well-followed habit (60.6 % marked always), other safety norms were neglected, nearly 15 % admitted to have food, drink or do smoke during agro-chemical uses and 13.57 % reported sniffing spray tanks. These behaviours sharply elevate the risk of different toxicological outcomes, as documented in studies by Mehta (2015) and Singh (2012).

Interestingly, while 78.7 % used separate measuring tools and 79.36 % prepared pesticide mixes outdoors, 75.59 % sprayed chemicals in the same direction as the wind blows, exposing themselves to drift contamination. Perceptions about preventive measures are divided 48.35 % deemed them worthwhile, while 20.83 % considered them ineffective, highlighting a need to bridge knowledge with perceived utility.

In terms of environmental perception, 54.95 % reported degradation in soil fertility and 42.32 % reported a decline in crop yield. More than 45 % of them linked chronic illnesses in their families to persistence agro-chemical exposures. Additionally, 92.93 % observed that water bodies were no longer safe for bathing, indicating awareness of ecosystem contamination.

Overall survey data reflect a high reliance on agrochemicals that coupled with poor access to scientific knowledge and inadequate adoption of safety measures. These patterns heighten the risk of cumulative toxicity and environmental degradation in the tribal agrarian setting of the Kelapur taluka (Yavatmal district), Vidarbha region, for years as an inevitable by-product of intensified agriculture practices, thus requiring proper attention in further.

Reproductive health in general reproductive wastage, age specific fertility rate (ASFR), surviving children rate, infant and under 5 child mortality rate in particular speaks volume of current demographic pattern and projected demographic trend of an ethnic group or a large population of any given area, as those are ever considered exclusive bio-social/cultural attributes of population dynamics, thus manifested with different forms or various societal conditions. Those parameters were also taken into consideration in this study and reproductive history of altogether 862 ever married women of their reproductive ages i.e. from 15 years to 49 years were interviewed on their reproductive histories in detail.

It reveals that only 44 women (5.10 %) had experience with menarche before attaining her 13 years of age. 139 women (16.12 %) attained menarche at the age of 13 years. Most of them (66.47 %) experienced menarche between 14 and 15 years of age. Late age at menarche (beyond 15 years) was reported relatively high (12.29 %), which indicates nutritional deficiencies or other health issues related to delays in puberty onset. Mean age at menarche in Kelapur taluka of Yavatmal is found 14.25 years (with S.D. value of ±1.26), which is much higher than mean age at menarche (12.96 years) in the tribal block of Palghar district of coastal Maharashtra, studied by Kulkarni *et al.* (2019) and also higher than the national average age at menarche in India, i.e. 13.49 years (NFHS -5, 2021), which is indicative to deeper regional disparities in health, nutrition and lifestyle.

Almost 60 % (59.51 %) of women got married between 15-19 years, indicating early marriage and found higher (23.2 %) women marriage before attaining 18 years of age in comparing to national data of NFHS-5. However, mean marriage age among 862 ever-married women is found 19.09 years (with S.D. value of ±2.60). While enquiring those ever-married tribal women on their age at first conception, it was reported almost half of them (52.59 %) had experienced with first time pregnancy in their's life during their ages 19-24 years of old. Interestingly, it was found that among rest of others, either they were conceived first time in their life before attending 19 years of age (37.37 %) or off-late (10.02 %) i.e. 25 years and above ages. However, mean age at first pregnancy is occurred 20.68 years of age (with S.D. value ±2.87). Simultaneously, this study also observed 106 (12.30 %) ever married women, who were reported that they already had experienced with menopause and that too were reported mostly in very early ages i.e. during 30 to 44 years of their ages.

Total Fertility Rate (TFR) among 862 ever-married women is an average of 2.02 pregnancies per women occurred during their reproductive span (Table 7.1.), which is as almost same 2.0 children per women to TFR in India (NHFS - 5) but little higher than rural Maharasthra (1.89). It is also observed that none of those ever-married women have had experiences with pregnancy during 15-19 years of age. Simultaneously, it is also noticed that though the live birth rate gradually increases in successive age groups but remarkably in a very low rate, which reported only 1.95 live births per women during the peak of their child bearing age i.e. 30-34 years of age that is even lower than successive reproductive ages. Overall reproductive wastage is reported 0.06 per woman which is significantly found lower than national average which is 0.11 per woman as per National Family Health Survey-5. Overall Age Specific Fertility Rate (ASFR) observed 1.95 live births per woman among 862 ever-married tribal woman of Kelapur taluka, Yavatmal district (Table 7.2.) ASFR among the studied women found highest (2.4 per woman) at 45-49 years age group. ASFR as per NFHS-5 (2021) report shows that fertility peaks in the early-20s, specifically during 20-24 years of ages and then thereafter declines sharply.

Surviving child ratio among the women refers status of live births and finally indicates status of surviving children of mothers. Out of 1688 live births, this study recorded 1610 live births with only 78 under 5 deaths among them. It shows (Table 7.3.) maximum value i.e. 2.19 surviving children per mother and 2.28 surviving children per mother in the age group 40-44 and 45-49 years. Overall, surviving children per women is noted 1.87 surviving children per mother against 1.95 live births thus advocates impressive reproductive-child health scenario among farmer families of Kelapur.

Gender scenario of live-birth and surviving children rate per mother of Kelapur tehsil, Yavatmal district. It reveals that there is no such remarkable difference between live births and survival chances among children of either gender but female children have higher survival chances than male children. Children deaths of different categories reveals out of 1688 live births, 78 (46 per 1000 livebirths) death observed under 5 years of age, which is higher than the national level under-5 mortality rate, which is 41.9 deaths per 1000 live births (NFHS-5). 80.76 % children died before completion of theirs one year age. Highest child's death (34.61%) had recorded among mothers belong to 35-39 years of age. Amongst under 5 children's death, maximum death had recorded as male children (53.84 %). Table 7.6 reveals 19.55/1000 neo-natal mortality rate per 1000 live births, which is lower than national neonatal mortality rate, is (24.9 per 1,000 live births), as recorded by NFHS-5. This indicates that neonatal care in Kelapur taluka (Yavatmal) better than the national scenario. but it is alarming in comparing the State neonatal mortality data (11 neonatal death per 1000 live births), as revealed in the Sample Registration System data (2021). As per NFHS-5, the national infant mortality rate (IMR) is

35.2 per 1,000 live births in compering, in Kelapur taluka (Yavatmal district) records a significantly lower IMR of 17.17 per 1,000 live births. This suggests that significant achievement in infant immunization-vaccination programmes as well as infant weanling and diet care thus had made notable progress in improving infant survival chances, while compared to the national scenario of IMR. However over-all child mortality (under 5 years) rate (46.20 death per 1000 live births) in Kelapur taluka presents higher rate than the national under 5 child mortality rate (42 deaths per 1000 live births), as per NFHS-5 data and also higher than Maharasthra state data (41.9 per 1000 live births) that demands further investigations.

Various kinds of morbid conditions have also explored in studied villages in general and every farmer household in particular. Across the study villages, morbidity and mortality patterns point to a high prevalence of illnesses that crest at predictable times of year and along familiar social lines. Vector-borne infections such as malaria, chikungunya, and dengue peak during the monsoon, while water- and food-borne illnesses—including typhoid, cholera, and diarrhoea—persist where sanitation and safe water access are limited. Alongside these, chronic pesticide-linked conditions manifest as vision loss, neurological weakness, cardiovascular disease, and renal disorders, and are increasingly accompanied by lifestyle illnesses such as hypertension, diabetes, and problematic alcohol use. Genetic and endemic conditions, notably sickle cell anaemia, add to this layered burden. Yet timely, effective care remains elusive. Many households live five to sixty kilometres from the taluka headquarters and more than a hundred kilometres from the district hospital; poor transport—especially in the monsoon—magnifies these distances. Private care is costly, with consultation fees and medicines placing heavy demands on cash-constrained families. Meanwhile, mistrust in government facilities persists due to absentee staff, curtailed hours, and frequent drug stock-outs, all of which push people toward delay, self-care, or informal providers.

Most common diseases in the study area over a period of 3 years (2022-2024) with accurate understanding of the key health issues among tribal farmers. Data reveal 81 cases under all categories of disease, cardiovascular and circulatory disorders being the most common health issue with 12 cases (14.81% of total cases). It is then followed by infectious and parasitic diseases at 9 cases (11.11%) and agrochemical induced vision conditions and sickle cell anaemia, both at 8 cases (9.88%). The burden of disease was predominantly found in 2024, with 36 cases (44.44% of total), while 28 cases (34.57%) were found in 2023 and 17 cases (20.99%) in 2022. Data indicate that a large number of cases are directly related to agricultural chemical exposure. Agro-chemical vision conditions (temporary vision loss) were a persistent issue throughout the study period, with 2 cases in 2022, 3 cases in 2023 and 3 cases in 2024, totaling of 8 cases (9.88%). Other pesticide induced conditions include cardiovascular effects (1 case), gastroenteropathy (1 case) and neuropathy (1 case), which reflect the multisystem effect of increased usage of agrochemicals in contemporary farming practices among the tribal population.

The spatial distribution of diseases as observed from Table 5.1, is an indication of the complicated epidemiological transition among intensive agriculture exposed tribal population. The predominance of cardiovascular disorders (14.81%) among tribal farmers represents a critical public health concern that extends beyond traditional occupational hazards. This increased cardiovascular burden is reflective of strong evidence purporting that pesticide toxic free radicals have a critical role in human health, with considerable evidence showing that pesticide exposure elevates the risk for cardiovascular disease development. Sickle cell disease (SCD) and sickle cell trait (SCT) cases varied across years, with 6 cases in 2023 compared to 1 case each in 2022 and 2024. Reported cases along with secondary and qualitative data, indicate an overall comparatively low frequency of SCD and SCT. Infectious and parasitic diseases was the second highest disease category with 9 cases (11.11%), which had an increasing trend from 3 cases in 2022 to 4 cases in 2024. Respiratory disease accounted for 5 cases (6.17%), with a significant increase from 1 case in both 2022 and 2023 to 3 cases in 2024. The temporal clustering of cases, and specifically the peak in 2024, represents complex interactions between patterns of healthcare seeking and illness behaviour among tribal farmers.

Overall morbidity data distribution by sex among 116 cases diagnosed (both farmers and agricultural labourers). Data present a wide gender difference in the pattern of disease with a total of 62.93% of the cases being males and 37.07% females. Cardiovascular and circulatory disorders are the most occurring disease burden (18.10% of total cases) that strikes more males (8.62%) than females (9.48%). Musculoskeletal Disorders make up 7.69% of the total cases, with a high male predominance (5.13% vs 2.56% in females), possibly due to the physically strenuous nature occupation that is usually the domain of men. Yet, qualitative findings reveal that joint pain is a prevalent health complaint among adults of both genders. Infectious and parasitic diseases account for 10.34% of all cases with significant male predominance (8.62% vs 1.72%), suggesting wider occupational or environmental risk factors which disproportionately impact men in farm environments. Agro-chemical induced conditions (vision) exhibit considerable gender differential with male predominance (6.90%) and no female cases (0.00%). This pattern is likely to be a manifestation of gendered segregation of farm labouring with higher male involvement in pesticides, insecticides and herbicides spraying, and handling. Gastrointestinal and hepatic diseases are present in 6.90% of the population with male dominance (4.31% vs 2.59%), whereas respiratory diseases involve 6.90% with equal male dominance (4.31% vs 2.59%). Renal and urological disorders are found in 6.03% of patients, involving just males in this population. Endocrine and metabolic disorders are found in 6.03% of the population but occur at a higher proportion in males (3.45% vs 2.59%). Sickle cell anaemia is found in 4.31% of the population and is more pronounced in females (3.45%) than in males (0.86%), suggestive of gender-specific presentation or detection rates. A few conditions have gender-specific patterns. Conditions of cyst or benign tumour predominantly afflict females (4.31% vs 0.86%), while conditions of agro chemical induced and renal disorders show male predominance. Infections and parasitic diseases have marked male predominance, suggesting wider occupational or environmental risk factors preferentially acting on men in agricultural environments. The morbidity pattern in Kelapur reflects the double burden of infectious diseases and incipient non-communicable diseases typical of populations in epidemiological transition. Significant rate of cardiovascular diseases (18.10%) in this tribal population is noteworthy with a marginal male excess (8.62% vs 9.48%), being consistent with expected trends where cardio-vascular diseases exhibit male predominance in workplaces.

Life-course analysis of morbidity patterns across physiological stages, in total 175 diagnosed cases reflects that adults are the vast majority among diagnosed cases (81.14%), followed by the elderly (13.71%) and there is insignificant representation of younger age groups (juveniles 2.29%, children 1.71%, infants 0.57%, and young children 0.57%). Adult population carries the greatest burden of disease, with cardiovascular and circulatory disorders being most common (14.29%), followed by infectious and parasitic diseases (9.14%), musculoskeletal disorders (8.0%) and respiratory disorders (6.29%). Prevalence of occupational diseases such as agrochemical induced vision conditions (5.14%) and respiratory diseases within the working age group is a clear demonstration of occupational exposures during working life. Age distribution pattern indicates the occupational health risks faced by the economically active adult population engaged in agricultural activities. Prevalence of agro-chemical related health conditions in adults (5.71% of all agro-chemical conditions) supports the occupational nature of these exposures. High burden of cardiovascular conditions (20.00%

of total cases) with predominant adult presentation (14.29%) reflects both occupational stress and lifestyle factors. Development of cardio-vascular conditions in older adults mirrors the natural history of chronic diseases but also reflects inadequately managed conditions in younger adult life. Prevalence of sickle cell anaemia among adults (4.57% of total cases, exclusively in adult population) can be attributed to survival patterns and detection practices in tribal populations. Relatively low paediatric disease burden (2.85% combined for all paediatric age groups) may reflect underutilization of childrens healthcare services, a characteristic pattern in tribal areas where limited access to healthcare remains a significant challenge.

Overall morbidity pattern of studied villages, including 175 diagnosed cases where males accounted for 59.43% and females 40.57% of cases. Cardiovascular and circulatory disorders represent the most significant health problem (20.00% of total cases), with greater female prevalence (12.00%) than male (8.00%). Infectious and parasitic diseases are second on the list (10.86%), with opposite gender distribution showing greater male prevalence (8.00%) than female (2.86%). Musculoskeletal disorders are third (9.14%), primarily involving males (5.14%) with notable female representation (4.00%). Endocrine and metabolic disorders account for 6.86% of cases with equal gender distribution (3.43% each). Study findings show an overall range of health conditions involving various cancers and tumours, metabolic, infectious and occupational diseases. Of note, agro-chemical induced vision conditions occurred in 6.29% of the population with a strong male predominance (5.71% vs 0.57%), while renal & urological disorders were noted in 5.71% of the population, predominantly affecting males (4.57% vs 1.14%). Gastrointestinal and hepatic disorders account for 6.29% of cases with male predominance (4.57% vs 1.71%). Respiratory diseases account for 6.29% of the cases and sickle cell anaemia represents 4.57% with female predominance (3.43% vs 1.14%). The occurrence of multiple neurological disorders (4.00% of cases) suggests either environmental exposures or genetic susceptibility, with slight male predominance (2.86% vs 1.14%).

High prevalence of agro-chemical induced vision conditions (6.29%) represents a critical occupational health emergency, with overwhelming male predominance (5.71% vs 0.57%). This finding concurs with research by Dhananjayan and Ravichandran (2018), which documented widespread pesticide related health effects in Maharashtra cottongrowing regions. The gender disparity reflects conventional farming practices but also points to limitations in occupational safety education and utilization of protective equipment. The 10.86% prevalence of infectious and parasitic diseases, with strong male predominance (8.00% vs 2.86%), significantly exceeds national norms and reflects the intersection of poverty, malnutrition and housing conditions typical in tribal communities. Studies conducted by Kaur et al. (2022) in tribal districts across India have shown similar trends, emphasizing socioeconomic determinants influence on disease transmission and outcomes. Broad spectrum of cancers and tumours observed (2.86% of total cases) may reflect environmental exposures, genetic predisposition, or delayed presentation patterns. Multiple studies have documented associations between exposure to agro-chemicals and cancer development, though definitive causal relationships require further investigation (Amizadeh et al., 2017; Ataei and Abdollahi, 2022). Equal gender distribution of these conditions suggests broader environmental rather than occupational specific exposures.

In summary, the overall morbidity analysis in Tables 5.1 to 5.4 reveals a complex health profile of tribal farmers in study area, typified by the convergence of traditional health problems with rising occupational and environmental health risks. Temporal patterns show continuous exposure to pesticide chemicals, while gendered patterns demonstrate the unequal impact of occupational activities and social determinants. The temporal analysis (Table 5.1) demonstrates persistent exposure to agro-chemical hazards across 2023-2024, with cardio-vascular disorders emerging as the leading health concern, followed by sickle cell anaemia and agrochemical induced vision conditions. The concentration of disease burden in 2024 (55.38% of all cases) reflects complex health-seeking patterns and potential clustering of health problems in tribal farming communities. Gendered patterns demonstrate the unequal impact of occupational activities and social determinants, with males bearing disproportionate burden of agrochemical induced vision conditions while cardiovascular disorders show unexpected female predominance. The life-course approach draws attention to the cumulative health risks, with the adult population shouldering the leading disease burden from occupational and lifestyle factors. The morbidity profile at the community level provides an epidemiological snapshot that reflects broader transitions occurring in tribal farming in central India. High prevalence of agro-chemical induced vision conditions, cardiovascular disorders and infectious diseases along with traditional health issues like sickle cell anaemia reflects the various health needs of rapidly transitioning communities in agricultural and socio-economic terms. The persistence of musculoskeletal disorders and respiratory conditions among working age adults demonstrates the physical toll of intensive agricultural practices combined with occupational exposures. However, the trend is not gender biased as it is common complaint in both the sexes.

These observations underscore the pressing need for holistic health interventions that cover both traditional health problems and emerging occupational health risks. The evidence demands convergent approaches combining occupational safety procedures, environmental health protection, genetic disease prevention and chronic disease control in culturally appropriate delivery systems. The morbidity profiles described in this research add to the emerging evidence base on tribal health in India, with implications for research and intervention programs aimed at reversing the unique health problems of indigenous farm communities against the backdrop of agricultural intensification and environmental change.

In understanding impact of changing cultivation practices an introspective approach had paid also to explore the mortality pattern among the farmers households. While research team was engaged in collecting household morbidity and mortality data, some of the informants reported the cause of deaths very precisely like cancer, malaria, diarrohea or else and others only could narrate some symptomatic descriptions of illness/diseases like 'tumor' "*pisah band ho gya tha, haath-pyr phul gyatha*" or "*burhapa*" etc. In such cases focused group interviews with villagers and ASHA workers helped in understanding of the illness/disease patterns in study areas and altogether 285 deaths were reported in the past ten years with reference year 2015-2025.

Overall mortality data, revealing significant gender and disease-specific patterns in the 285 deaths (146 males, 139 females) observed within the study population. Elderly natural death (28.77%), cardiovascular and circulatory diseases (14.04%), and unnatural death (12.28%) were the top three contributing causes of death, reflecting a mortality pattern that suggests both natural aging processes and significant burdens from cardiovascular disease and external causes of death prevalent in this tribal population. Elderly natural death was the leading cause of mortality at 28.77% (82 cases), with a higher burden among females (16.49%, 47 cases) compared to males (12.28%, 35 cases). This substantial proportion reflects the demographic characteristics of the study population and suggests longer life expectancy among females in this tribal community. Cardiovascular and circulatory diseases accounted for 14.04% of mortality (40 cases), with a slightly higher burden among females (7.37%, 21 cases) compared to males (6.67%, 19 cases). Substantial death burden represents the epidemiological transition occurring in tribal populations, where non-communicable diseases increasingly dominate over communicable diseases, aligning with observations from tribal regions of central India (Sathiyanarayanan et al., 2019). Unnatural death was the third highest leading cause of death (12.28%, 35 cases), with a markedly higher mortality among males (10.18%, 29 cases) compared to females (2.11%, 6 cases). These deaths include occupational and road accidents (15), suicides (17) and Animal bites (3). This represents a substantial gender disparity in external causes of mortality, with males accounting for 82.9% of all unnatural deaths. This pattern of suicides is reflective of the wider agrarian crisis across the cotton cultivating districts of Vidarbha region, where farmer deaths have reached epidemic proportions, caused by crop failure, increasing costs of cultivation, and mounting debt burdens (Behere & Behere, 2008). A study revealed that debt, addiction, environmental problems, poor price realization for agricultural produce, and family responsibilities are major factors that are perceived as major contributing factors for farmer suicides in Vidarbha region (Dongre & Deshmukh, 2012). Another study reported that crop failure, indebtedness, economic crisis, unemployment, and lack of social support contribute significantly to mental distress among farmers in Yavatmal (Bomble & Lhungdim, 2020). Though certain infectious conditions that comes under the category of affected organ, they were classified under infectious diseases such as TB except jaundice and hepatitis which were classified under gastrointestinal and liver disorders. Further. brain fever is classified under infectious diseases. Infectious and parasitic diseases contributed to 7.37% of mortality (21 cases), with a higher burden among females (4.21%, 12 cases) compared to males (3.16%, 9 cases). Pulmonary Tuberculosis, brain fever, COVID-19 and othe variants, leprosy, pneumonia with incomplete TB treatment and sepsis are categorised in this group. Although representing a smaller proportion, this still indicates a significant burden, when compared with national averages. Tuberculosis prevalence has been reported in tribal prevalence surveys to be 703 per 100,000 against the national prevalence of 256 per 100,000, with highly vulnerable tribes like Saharia in Madhya Pradesh reaching 1,518 per 100,000 (Rao et al., 2015; Narain, 2019). Cancers showed a notable gender disparity, affecting 4.56% of males (13 cases) compared to 2.11% of females (6 cases), contributing to 6.67% of total mortality (19 cases). This represents more than double the cancer mortality rate among males compared to females. Respiratory Diseases accounted for 6.32% of mortality (18 cases), with a higher burden among females (3.86%, 11 cases) compared to males (2.46%, 7 cases). Renal and urogenital diseases contributed to 5.61% of mortality (16 cases), with a sligtly higher burden among females (3.16%, 9 cases) compared to males (2.46%, 7 cases). Vector-borne Diseases accounted for 3.51% of overall mortality (10 cases), with a higher burden among females (2.11%, 6 cases) compared to males (1.40%, 4 cases). The Vector-borne Disease category includes dengue, malaria, and chikungunya. This concurs with studies showing that tribal populations, though they account for approximately 8% of India's population, contribute

47% of all malaria cases, 70% of falciparum malaria, and 46% of deaths due to malaria (Dhariwal & Singh, 2015). The endemicity of vector-borne disease among Maharashtra tribal communities has been extensively reported, with about 50% of the overall malaria mortality in India being among the tribal population (Jain et al., 2015).

Age-stratified mortality data in Table 6.2 reveals distinct patterns across different life stages, emphasizing the vulnerable phases and disease-specific risks faced by the tribal population. The data shows that mortality is heavily concentrated in two age groups: adults (15-64 years) accounting for 52.28% of all deaths (149 cases) and elderly (65+ years) represents 45.26% (129 cases). Infant and child mortality (under 5 years) was relatively low, with only 5 deaths total (1 infant under 12 months and 4 children 12-59 months), representing 1.75% of all mortality. The single infant death was attributed to unnatural causes. In the child group (12-59 months), deaths were attributed to neurological and mental health problems (1 case), gastrointestinal and liver disorders (1 case), and vector-borne diseases (1 case), with one case unspecified in the table data. Young child (5-9 years) and juvenile (>9-<14 years) groups showed minimal mortality, with only 1 death in the young child group (cancer/tumor) and 2 deaths in the juvenile group (both unnatural deaths). This low pediatric mortality suggests relatively effective maternal and child health interventions or improved living conditions compared to historical patterns. Child mortality (0-14 years) was relatively low in the study population (6 deaths, 2.1%), indicating partial success in child survival programs, though underreporting of early childhood mortality can not be ruled out. However, the observations establish the fact that there is an improvement and success in the targeted health programmes. The NFHS 5 data indicate that under five mortality among Scheduled Tribes continues to be high when compared to the general population, with tribal populations having 50 deaths per 1,000 live births compared to the national average of 41.9 deaths per 1,000 live births and that tribal populations have 41.9 deaths per 1,000 live births (International Institute for Population Sciences [IIPS] & ICF, 2021; Kunjumon et al., 2024). Further, the persistence of these health and mortality disparities in scheduled tribe populations across India are confirmed by comparative analyses (Subrabanian & Joe, 2023). Gender trends revealed higher mortality among males in all age groups, consistent with national demographic trends but especially marked among the working-age groups (15-64 years), where lifestyle variables, work related risks and suicidal risk account for excess male deaths. Adult mortality showed the highest diversity in causes of death and represented the largest burden at 52.28% of total deaths. The leading causes in this age group were unnatural death (causing road accidents, suicide, homicide, and animal attack) with 26 cases (9.12% of total mortality), representing the highest single cause of death in adults and highlighting significant external mortality risks. Cardiovascular and circulatory diseases contributed 25 cases (8.77%), indicating substantial burden of non-communicable diseases in the productive age group. Infectious and parasitic diseases accounted for 14 cases (4.91%), showing continued vulnerability to communicable diseases. Both cancers/tumors and renal/urogenital disorders each contributed 13 cases (4.56%), demonstrating significant disease burden during productive years. Other causes of natural deaths accounted for 12 cases (4.21%), suggesting premature aging or potential misclassification of deaths in this population. Other notable causes included respiratory diseases (8 cases, 2.81%), maternal and perinatal & gynaecological conditions (5 cases, 1.75%), vector-borne diseases (5 cases, 1.75%), and sickle cell anemia (4 cases, 1.40%). Elderly mortality was dominated by natural aging processes, with elderly natural death accounting for 70 cases (24.56% of total mortality). However, several other conditions contributed significantly to elderly deaths including cardiovascular and circulatory diseases with 15 cases (5.26%), showing continued burden into advanced age. Respiratory diseases contributed 10 cases (3.51%), reflecting increased vulnerability of aging respiratory systems. Infectious and parasitic diseases accounted for 7 cases (2.46%), indicating continued susceptibility to communicable diseases. Unnatural death contributed 6 cases (2.11%), showing that external causes affect all age groups. Cancers/tumors accounted for 5 cases (1.75%), with lower burden than in adult years, while vector-borne diseases contributed 4 cases (1.40%), reflecting continued exposure risks throughout the lifespan.

Cancer distribution shows 19 total cases distributed as 13 in adults (4.56%), 5 in elderly (1.75%), and 1 in the young child group (0.35%). This adult predominance could indicate environmental or occupational exposures requiring further investigation. Vector-borne diseases showed minimal occurrence in pediatric groups (1 case in children 12-59 months), moderate burden in adults (5 cases, 1.75%), and continued presence in elderly (4 cases, 1.40%), suggesting lifelong exposure risks in this endemic region. Unnatural deaths totaling 35 cases were distributed as 1 infant (0.35%), 2 juveniles (0.70%), 26 adults (9.12%), and 6 elderly (2.11%). The overwhelming concentration in the adult age group (74.3% of all unnatural deaths) highlights the critical risk period for external causes of death, consistent with agricultural crisis patterns documented in the Vidarbha region. Prevalence of both communicable and non-communicable diseases across age groups indicates an incomplete epidemiological transition in this tribal population. Substantial burden of cardiovascular diseases (40 cases total) and cancers (19 cases total) coexists with continued risks from infectious diseases (21 cases) and vector-borne diseases (10 cases). This dual disease burden pattern is consistent with findings from other tribal areas in central India, where traditional infectious disease risks persist alongside emerging non-communicable disease challenges (Jain et al., 2015). The concentration of mortality in adult and elderly age groups (97.54% combined) with relatively low pediatric mortality suggests improvements in early life survival while highlighting the growing burden of adult and elderly health challenges in this tribal community.

Mortality profile of 187 farmers who died in the Kelapur Taluka of Yavatmal District, Maharashtra, categorised by diagnosed diseases causing death and disaggregated by sex. The data indicates notable patterns in cause of death among tribal farming communities, with 52.90% (99 deaths) of total mortality reported by males and 47.10% (88 deaths) reported by females. The highest category of death is elderly natural death, accounting for 57 deaths (30.50% of total deaths), representing the single largest cause of mortality among farmers in this tribal community. This trend indicates that even with agricultural intensification, natural aging remains the major cause of death among this tribal farming population. Cardiovascular and circulatory diseases constitute a significant mortality burden, accounting for 15.00% of all deaths (28 cases) with equal distribution between males and females (14 cases each). This relatively equal gender distribution in cardiovascular mortality contrasts with general urban trends where males have greater prevalence, implying specialized environmental or occupational risk factors in agricultural areas. The substantial burden of cardiovascular disease reflects the epidemiological transition occurring in rural tribal populations. Unnatural deaths (accidents, suicide, homicide and animal attack) emerges as a critical concern, representing 10.70% of all fatalities (20 cases) with a dramatic gender imbalance of 18 men (9.60%) compared to just 2 women (1.10%). This pattern concurs with the wider agrarian crisis literature on farmer suicides, specifically among male farmers under economic stress due to agricultural intensification and debt burdens prevalent in the Vidarbha region. Respiratory disease affected 7.00% of the population (13 cases), with females showing higher mortality (8 cases, 4.30%) compared to males (5 cases, 2.70%). This differential may result from differential exposure patterns where women experience greater exposure to indoor air pollution from cooking practices or specific farming activities involving dust and agricultural residues. Vector-borne diseases and infectious & parasitic diseases each account for 6.40% of overall mortality (12 cases each), representing significant public health challenges in this tribal agricultural population. The high proportion results from the convergence of environmental degradation, climate change, and farming practices that create favorable conditions for disease vectors while disrupting natural ecological balances. Cancer related mortality contributes 4.80% of deaths (9 cases), with a notable gender disparity showing 7 male deaths (3.70%) compared to 2 female deaths (1.10%). The occurrence of various cancer types indicates probable exposure to carcinogenic substances via agricultural chemicals, though definitive causality requires further investigation. Renal and uro-genital problems cause 5.30% of mortality (10 cases), possibly due to exposure to agricultural pesticides, contaminated drinking water sources, or chronic dehydration from agricultural labor under extreme climatic conditions. This burden is particularly concerning given the known nephro-toxic effects of certain pesticides commonly used in cotton cultivation. Several other conditions contribute to the mortality profile, including gastrointestinal and liver disorders (2.70%), blood and genetic disorders (1.60%), maternal and peri-natal problems (1.60%), and neurological/mental health issues (1.60%). Unclassified deaths account for 4.30% of cases, indicating potential gaps in diagnostic capabilities or death certification processes.

Vidarbha's tribal farmers' mortality profile exhibits both convergences and divergences from wider Indian health trends. While cardiovascular diseases represent a major cause of death consistent with national patterns, the prevalence of vector-borne diseases (6.40%) and unnatural deaths (10.70%) are substantially higher than national averages, reflecting regional environmental factors and inadequate public health infrastructure in tribal communities. 10.70% unnatural death rate is particularly concerning when viewed against Maharashtra's status as a leading state for farmer suicides. According to studies, debt pressures, crop loss, and social exclusion factors, possibly worsened by agricultural intensification, contribute to this alarming trend (Behere & Behere, 2008). The pattern of observed mortality indicates several ways in which intensification of agriculture affects health outcomes. The occurrence of cancers, renal disease, and respiratory diseases aligns with reported health effects of pesticide exposure, as documented in studies by Mesnage and Antoniou (2018) and Curl *et al.* (2020) in comparable agricultural settings. High burden of vector-borne diseases may reflect ecological disturbances linked to intensive agriculture, where monoculture production, augmented irrigation, and pesticide resistance create favorable environments for disease vectors while disrupting natural predator-prey dynamics that once regulated vector populations (Rivero et al., 2010). This complex interplay between agricultural practices and health outcomes underscores the need for comprehensive approaches to address both agricultural sustainability and farmer health in tribal communities.

A comprehensive temporal analysis of 141 deaths for a period over five years (2020 – 2024) in the study area reveals 66 male deaths (46.81%) and 75 female deaths (53.19%). Data reveals distinct temporal patterns across different disease categories and demonstrates evolving mortality trends in this tribal population over the five-year study period. Elderly natural death emerges as the leading cause of mortality across all years, accounting for 41 deaths (29.08% of total mortality) with a notable female predominance (25 cases, 17.73%) compared to males (16 cases, 11.35%). The temporal distribution shows 9 deaths in 2024 (29.03% of that year's deaths), 8 deaths each in 2023 (30.77%) and 2022 (30.77%), 7 deaths in 2021 (20.59%), and 9 deaths in 2020 (37.50% of that year's deaths). The sustained prominence of elderly natural death reflects the aging demographic structure of this tribal population. Cardiovascular and circulatory diseases constitute the second major mortality burden, accounting for 17 deaths (12.06% of total mortality) with a slight female predominance (9 females vs 8 males). The temporal pattern shows notable fluctuations: 6 deaths in 2022 (23.08% of that year's deaths), 5 deaths each in 2024 (16.13%) and 2021 (14.71%), 1 death in 2020 (4.17%), and no deaths recorded in 2023. This varying pattern may reflect seasonal factors, diagnostic capabilities, or genuine temporal variations in cardiovascular risk factors. Unnatural death represents a critical public health concern, accounting for 15 deaths (10.64% of total mortality) with a stark gender disparity showing 12 male deaths (8.51%) compared to only 3 female deaths (2.13%). The temporal distribution reveals 5 deaths in 2024 (16.13% of that year's deaths), 4 deaths each in 2022 (15.38%) and 2020 (16.67%), 3 deaths each in 2023 (11.54%) and 2021 (8.82%). This persistent burden across all years, with overwhelming male predominance (80% of unnatural deaths), reflects the ongoing agrarian crisis and mental health challenges facing male farmers in the region. Infectious and parasitic diseases contributed 10 deaths (7.09% of total) with female predominance (6 cases vs 4 males). The temporal distribution shows a declining trend from 6 deaths in 2021 (17.65% of that year's deaths) to 2 deaths in 2023 (7.69%), 1 death each in 2024 (3.23%) and 2022 (3.85%), with no deaths recorded in 2020. This declining trend may indicate improved healthcare access or successful public health interventions. Cancer-related mortality shows 9 deaths (6.38% of total) with male predominance (7 cases vs 2 females). The temporal distribution reveals 3 deaths each in 2020 (12.50% of that year's deaths) and 2022 (11.54%), 2 deaths in 2021 (5.88%), 1 death in 2024 (3.23%), and no deaths recorded in 2023. The consistent presence across multiple years, with male predominance, may reflect occupational exposures to agricultural chemicals or lifestyle factors. Renal and uro-genital problems account for 9 deaths (6.38% of total) with female predominance (6 cases vs 3 males).

Temporal clustering shows 4 deaths in 2024 (12.90% of that year's deaths), 3 deaths in 2021 (8.82%), 2 deaths each in 2020 (8.33%) and 2023 (7.69%), with no deaths recorded in 2022. This pattern may reflect cumulative effects of agricultural chemical exposure or varying environmental stressors affecting kidney health. Respiratory diseases contributed 9 deaths (6.38% of total) with strong female predominance (8 cases vs 1 male). The temporal distribution shows 4 deaths in 2023 (15.38% of that year's deaths), 3 deaths in 2021 (8.82%), 1 death each in 2024 (3.23%) and 2020 (4.17%), with no deaths recorded in 2022. The female predominance may reflect differential exposure patterns, including indoor air pollution from cooking practices. Vector-borne diseases account for 8 deaths (5.67% of total) with slight male predominance (5 cases vs 3 females). The temporal distribution shows 2 deaths in 2023 (7.69% of that year's deaths), 1 death each in 2024 (3.23%), 2021 (2.94%), and 2020 (4.17%), with no deaths recorded in 2022. The persistent presence across multiple years indicates sustained endemicity of vector-borne diseases in the region. Gastrointestinal and liver disorders account for 4 deaths (2.84% of total) with equal gender distribution (2 females, 2 males). Sickle cell anemia contributed 4 deaths (2.84%) with female predominance (3 cases vs 1 male), showing 2 deaths each in 2023 (7.69% of that year's deaths) and 2021 (5.88%). Neurological and mental health issues contributed 4 deaths (2.84%), distributed as 2 deaths in 2024 (6.45%), 1 death each in 2023 (3.85%) and 2020 (4.17%). Endocrine and metabolic disorders contributed 2 deaths (1.42%), both occurring in males during 2023 and 2022. Hepatitic conditions accounted for 2 deaths (1.42%), both in females during 2024 and 2022. Unclassified deaths contributed 4 deaths (2.84%), with 2 deaths each in 2022 (7.69%) and 2020 (8.33%). Maternal and perinatal conditions contributed 1 death (0.71%) in 2021.

Temporal trends reveal several important patterns. The persistence of unnatural deaths across all time periods reflects the ongoing agrarian crisis in the Vidarbha region, where cotton farming difficulties and debt burdens continue to affect farmer mental health. Literature has shown that 95% of cotton growers in Vidarbha face enormous debt burdens (Kennedy & King, 2014), while studies from Yavatmal District reveal that 58% of farmers suffer from mental health stress, with anxiety and insomnia being the most prevalent symptoms (55%) (Bomble & Lhungdim, 2020). Fluctuating patterns in cardiovascular diseases, with complete absence in 2023, suggest complex interactions between environmental factors, healthcare access, and disease surveillance capabilities. The declining trend in infectious diseases from 2021 onwards may indicate improved healthcare interventions or changes in disease exposure patterns. The consistent burden of elderly natural deaths across all years reflects demographic transitions, while the persistent cancer burden, particularly among males, warrants investigation into occupational and environmental risk factors associated with intensive agricultural practices in tribal communities. The sustained presence of vector-borne diseases across multiple years is consistent with studies demonstrating that tribal regions maintain malaria as a leading cause of morbidity and mortality (Chourasia et al., 2017). The clustering of renal disease deaths in recent years (2024 showing the highest burden) may reflect cumulative effects of long-term exposure to agricultural chemicals or environmental pollutants, highlighting the need for targeted interventions addressing occupational health risks in farming communities.

Table 6.5 presents a comprehensive analysis of cause-specific mortality patterns across COVID-19 (2020-2021), post-Covid (2022-2023), and pre-Covid (2015-2019) periods among 285 deaths in the studied tribal villages, with 139 female deaths (48.77%) and 146 male deaths (51.23%) altogether. Temporal analysis reveals significant shifts in disease patterns and mortality trends associated with the COVID-19 pandemic and its aftermath. The COVID-19 period recorded 58 deaths (20.35% of total mortality) with notable gender distribution showing 25 female deaths (43.10%) and 33 male deaths (56.90%) during this acute phase. Elderly natural death emerged as the leading cause with 16 deaths (27.59% of COVID period deaths), followed by unnatural death and cardiovascular diseases each with significant burdens. The predominance of elderly deaths during this period reflects the known age-related vulnerability to COVID-19, while cardiovascular complications align with documented COVID-19 comorbidities. Indigenous populations showed vulnerability to COVID-19 as they had minimal contact with outside pathogens, making them more susceptible to novel infections (Kshatriya & Acharya, 2016). The post-Covid period showed 84 deaths (29.47% of total mortality) with a shift in gender distribution to 46 female deaths (54.76%) and 38 male deaths (45.24%). Elderly natural death remained dominant with 25 deaths (29.76% of post-Covid deaths), followed by unnatural death with 12 deaths (14.29%) and cardiovascular diseases with 11 deaths (13.10%). The persistent burden of cardiovascular diseases in this period may reflect delayed healthcare access and chronic disease management disruptions caused by the pandemic. Maharashtra experienced significant impact on life expectancy during COVID-19, with age-specific case fatality rates increasing with age, reaching 7% by age 60 and 11% in those aged 80 and above (Vasishtha et al., 2021). Pre-Covid period recorded 143 deaths (50.18% of total mortality), shows 68 female deaths (47.55%) and 75 male deaths (52.45%). Elderly natural death dominated with 41 deaths (28.67% of pre-Covid deaths), followed by cardiovascular diseases with 23 deaths (16.08%) and unnatural death with 16 deaths (11.19%).

This baseline pattern reflects the ongoing epidemiological transition in tribal populations, where tribal communities are experiencing rapid increases in non-communicable diseases such as hypertension, diabetes, and cardiovascular diseases alongside traditional disease burdens (Narain, 2022). The data reveals several critical temporal patterns across the three periods. Cardiovascular mortality showed variation across periods with 23 deaths in Pre-Covid (16.08% of that period), 6 deaths in COVID-19 (10.34%), and 11 deaths in post-Covid (13.10%), reflecting both direct COVID-19 effects and healthcare disruption impacts. Rural India has experienced an epidemiological transition with NCD burden increasing from 35.9% to 54.9% while communicable disease burden declined from 47.7% to 22.1% during recent decades (Yadav and Arokiasamy, 2014). Cancer mortality demonstrated notable temporal clustering with 10 deaths in pre-Covid (6.99% of that period), 5 deaths in COVID-19 (8.62%), and 4 deaths in post-Covid (4.76%), showing potential diagnostic delays during the pandemic. The COVID-19 period showed an unusually high proportion of cancer deaths, possibly reflecting delayed diagnosis leading to more severe presentations. Unnatural death patterns revealed persistent mental health challenges across all periods, with clear male predominance evident in pre-Covid (13 males vs 3 females) and post-Covid (9 males vs 3 females) periods, while COVID-19 period showed 7 males with no female unnatural deaths. The consistent burden of unnatural deaths reflects ongoing agrarian distress in the Vidarbha region, where farming communities face chronic economic pressures and mental health challenges (Bomble & Lhungdim, 2020). Infectious and parasitic diseases showed interesting temporal variations with 11 deaths in Pre-Covid (7.69% of that period), 6 deaths in COVID-19 (10.34%), and 4 deaths in post-Covid (4.76%), potentially indicating improved infection control measures or reduced healthcare seeking during pandemic restrictions. Vector-borne diseases-maintained presence across periods with 5 deaths in Pre-Covid (3.50%), 2 deaths in COVID-19 (3.45%), and 3 deaths in post-Covid (3.57%), demonstrating persistent endemicity in the region despite public health interventions (Chourasia et al., 2017). Renal and urogenital problems showed stability across periods with 5 deaths in Pre-Covid (3.50%), 5 deaths in COVID (8.62%), and 6 deaths in post-Covid (7.14%), possibly reflecting chronic environmental exposures from agricultural chemicals. The COVID-19 period showed a proportionally higher burden of renal disease, which may be related to COVID-19's known effects on kidney function. Respiratory diseases demonstrated variation with 9 deaths in Pre-Covid (6.29%), 4 deaths in COVID (6.90%), and 5 deaths in post-Covid (5.95%). Despite COVID-19 being a respiratory illness, the proportion remained relatively stable, possibly indicating that other respiratory conditions continued to affect this population.

Gender specific mortality patterns during the COVID period showed a notable shift toward male mortality (56.90% vs 43.10% female), contrasting with the more balanced distributions in other periods. This pattern aligns with global observations of higher COVID-19 mortality among males. The post-Covid period reversed this trend with female predominance (54.76% vs 45.24% male), possibly reflecting delayed healthcare effects or other indirect pandemic impacts on women.

In understanding the public health implications, mortality patterns reveal the complex interplay between pandemic effects and underlying health system challenges in tribal communities. Life expectancy in India declined by approximately 2.0 years in 2020 compared to 2019, with negative impacts more pronounced among men (Yadav et al., 2021). The data suggests that while direct COVID-19 mortality was significant in this rural tribal population, indirect effects through healthcare disruption and socioeconomic impacts were substantial (Mittal et al., 2023). Persistent dominance of elderly natural death across all periods (41 Pre-Covid, 16 COVID, 25 Post-Covid) reflects both demographic transitions and potential gaps in chronic disease management. Tribal populations face a triple burden of undernutrition, obesity, and cardiovascular disease risks due to socio-cultural transitions and epidemiological changes (Kshatriya & Acharya, 2016). The temporal analysis underscores the need for strengthened health systems capable of managing both communicable and non-communicable disease burdens while maintaining essential services during health emergencies, with targeted interventions addressing mental health support for farmers, cardiovascular disease prevention and management, and continued vector control programs in tribal communities.

Table 6.6 analysis of mortality by family relationships reveals critical patterns in household mortality, reflecting demographic transitions and socio-economic vulnerabilities in the population. The data includes 285 deaths across various kinship categories and disease classifications, providing insights into family-level health burdens and gender-specific mortality risks. Mother, father and children all contributed significantly to mortality rates. Mothers had the highest mortality burden at 32.28%, followed by fathers at 27.72%, accounting for 60.00% of all household deaths. This maternal mortality concentration has implications for household stability, economic continuity, and intergenerational support systems. Disease-specific mortality patterns reveal significant epidemiological insights. Cardiovascular and circulatory diseases emerged as the leading cause at 14.04%, with mothers accounting for

32.50%, fathers 22.50%, husbands 15.00%, and wives 15.00% of these deaths. Unnatural deaths, comprising 12.28% of total mortality, showed a striking gender disparity, with husbands accounting for 40.00%, sons 20.00%, and fathers 11.43%. This highlights significant occupational and psychosocial risks, particularly among male household members who often engage in hazardous agricultural work and bear primary economic responsibilities. Data reveals distinct gendered mortality patterns that reflect differential health vulnerabilities and social roles within households. Mothers had the leading causes of elderly natural death, cardiovascular diseases, and infectious diseases, while fathers had the highest proportion of unnatural deaths. The high proportion of unnatural deaths among husbands suggests acute stress factors affecting younger male household heads, potentially related to agricultural distress, debt burdens, and economic pressures. Mortality distribution across kinship roles provides a life-course perspective on household health vulnerabilities. The concentration of deaths among parents at 60.00% indicates an aging population with increasing care needs and declining traditional support systems. The presence of deaths among younger family member's points to persistent challenges in child and young adult health, likely related to infectious diseases, maternal and perinatal conditions, and inadequate access to preventive healthcare services. This multigenerational mortality pattern suggests that households face compound health risks across the life span, requiring comprehensive approaches to family health that address age-specific vulnerabilities while strengthening household resilience.

Traditional healing practice is now being a fading tradition in Kelapur, as so the institutions of traditional healers almost lost significance in community services. Despite a long-term decline in their numbers, traditional healers continue to hold cultural authority and practical relevance, especially in villages such as Wai and Ganeshpur. Healers like Rama Chandu Tekam (Kolam) and Kaudu Jangaji Kolape (Gond)—the latter combining indigenous knowledge with Ayurveda training—tend to conditions ranging from epilepsy, jaundice, and fractures to snake bite, with locally specific classifications of fevers and dietary prescriptions. Diagnosis may involve pulse-reading, ritual divination, and careful observation, while treatment blends herbal preparations with chants and regimen. Even as biomedical services expand, these practitioners often function as first points of contact, particularly for ailments that communities interpret in spiritual or customary terms. Their continued use is not simply about habit; it also reflects the affordability, accessibility, and cultural fit of their care in comparison to distant, unpredictable formal services. Formal biomedical care reaches to tribal areas through Sub-PHCs, PHCs, and the Sub-District Hospital at Kelapur. In practice, however, utilisation is constrained by chronic staffing shortages—many PHCs see doctors only two or three times a week—along with recurrent medicine shortages that force patients to buy drugs from private pharmacies. In emergencies such as pesticide poisoning or complicated deliveries, referrals to the district hospital in Yavatmal, 43–110 Kilometres away, are common, but travel time, cost, and coordination make such referrals risky. Despite these barriers, households still prefer biomedical care for severe or persistent conditions, especially cardiovascular disease, suspected cancers, and cases requiring surgery, which underscores both the perceived efficacy of allopathic treatment for critical illness and the need to make such services reliably accessible. Between traditional and formal care sits a dense layer of household and informal practices that fill everyday gaps. Families frequently resort to over-the-counter painkillers, antipyretics, and antibiotics purchased from local shops without prescriptions, a pattern shaped by cost, proximity, and habit. Home remedies—herbal teas for fever, turmeric for wounds, *neem* for skin rashes—remain common, as do faith-based strategies that include temple visits, ritual offerings, and fasting when illness is believed to have spiritual causation. These approaches do not necessarily exclude biomedical care; rather, they create a practical ladder of options that families climb as symptoms linger, money becomes available, or advice from kin and neighbours shifts. Alcohol use emerged as a major health and social concern, particularly among men who often begin drinking before the age of twenty. Drinking is woven into social life and is frequently rationalised as a response to agricultural uncertainty and financial pressure. Alcohol-related harms—liver disease, gastritis, injuries, and accidents—were common and materially affected treatment-seeking. Intoxication delayed recognition of serious symptoms, reduced adherence to medical advice, and sometimes led to outright refusal of biomedical care. In this way, alcohol not only contributes directly to morbidity but also undermines timely and effective engagement with the health system. Gender preferences profoundly structured in the pathways to healthcare practices. Women face layered barriers—domestic responsibilities, limited control over household finances, and dependence on male decision-makers for travel—which delay consultations for reproductive and chronic health problems. Many first seek help from traditional healers or rely on home remedies, reaching biomedical services only when conditions worsen. Men are more likely to present for acute occupational injuries and pesticide-related episodes, though they also delay care due to work demands or alcohol use. Children are usually brought promptly to PHCs for fever and diarrhoea, yet neonatal and early-infant care remains uneven, with gaps in timely referral and follow-up contributing to avoidable complications and, at times, mortality.

Analytical framework of this study integrated both bivariate and multivariate statistical techniques, supplemented with anthropological interpretation, to explore the complex linkages between agricultural practices, agro-chemical exposures, morbidity, mortality, and reproductive outcomes. This approach ensured that the results were not reduced to isolated numerical outputs but instead situated within the broader bio-cultural realities shaped by ecology, patterns of labour, and social structures.

The bivariate results revealed distinct patterns. Households engaged in cash crop cultivation, particularly cotton and soybean, reported significantly higher morbidity rates, especially with respect to cardiovascular and agro-chemical-induced conditions, and these associations were statistically significant ($p < 0.05$). Households that stored pesticides and herbicides inside their homes were 1.6 times more likely to report miscarriages and showed generally higher morbidity. Landholding size also displayed a dose–response pattern, with larger landholders applying more chemicals and subsequently reporting higher morbidity. These findings clearly demonstrate that health risks are not randomly distributed across the population but are patterned along socio-economic and occupational lines.

Binary logistic regression models highlighted pesticide exposure as a particularly strong predictor of morbidity. The odds of cardiovascular morbidity were found to increase more than twofold (OR = 2.1) in pesticide-exposed households. Renal morbidity was also significantly higher (OR = 1.9), and agro-chemical-induced ocular and neurological conditions had an even stronger association (OR = 2.3). Household chemical storage was independently associated with child morbidity (OR = 1.7), underscoring domestic exposure pathways. Sex also emerged as a modifying factor: men faced higher risks of cardiovascular and renal morbidity, while women bore greater risks of reproductive disorders. Importantly, even after controlling for age, sex, and family structure, agrochemical exposure remained a significant predictor, reinforcing the robustness of these findings.

Cox proportional hazards models provided insights into cause-specific mortality. Cardiovascular mortality hazards were more than doubled (HR = 2.2) among pesticide-exposed households, while cancer mortality showed a hazard ratio of 1.8, highlighting the long-term toxicological consequences of chronic exposure. Although unnatural deaths clustered in working-age males, regression models suggested that these were indirectly associated with agricultural distress and pesticide-related financial pressures, rather than purely occupational risks. These models make clear that agro-chemical exposure does not merely increase morbidity but actively shortens survival, particularly with respect to chronic non-communicable diseases.

Reproductive health was analysed using multinomial logistic regression to differentiate between women experiencing no reproductive events, miscarriage, or stillbirth. Pesticide exposure significantly increased the risk of both miscarriage (RRR = 1.75) and stillbirth (RRR = 2.05). Herbicide exposure showed a trend toward higher stillbirth risk (RRR = 1.66), though its confidence interval crossed unity, suggesting a borderline effect. Household proximity to chemical storage raised miscarriage risk by 58 percent, further confirming domestic vulnerability pathways. These findings resonate with earlier studies such as Rupa et al. (1991), reinforcing the conclusion that agricultural intensification carries profound reproductive costs.

Principal Component Analysis (PCA) clustered households into three broad groups. The first comprised high-exposure households—those cultivating cotton and soybean with large landholdings and storing chemicals indoors. These households clustered with high rates of cardiovascular, renal, and reproductive morbidity. The second group, moderate-exposure households were engaged in mixed cropping with relatively limited pesticide use and experienced correspondingly lower morbidity. Finally, low-exposure households, often landless labourers with minimal direct exposure to spraying, displayed higher incidences of infectious diseases but fewer non-communicable disorders. These clusters illustrate how landholding patterns, crop choice, and chemical use structurally embed health outcomes.

Correlation matrices provided further insights into exposure–outcome linkages. Pesticide exposure showed strong positive correlations with cardiovascular morbidity ($r = 0.30$, $p = 0.004$), while herbicide exposure displayed moderate correlations with renal morbidity ($r = 0.26$, $p = 0.011$). Household proximity to stored chemicals correlated not only with general morbidity but also with reproductive wastage. Heatmaps visualised these associations, clearly demonstrating that chemical exposures were central determinants of health, with non-communicable diseases and reproductive losses clustering tightly around them.

Statistical outputs were reinforced through visual narratives. Forest plots effectively illustrated the heightened relative risks for miscarriage, stillbirth, cardiovascular conditions, and cancer mortality among pesticide-exposed households. Sankey diagrams mapped the flows from socio-economic contexts—such as landholding and crop choice—through exposure pathways to morbidity, mortality, and downstream socio-economic burdens such as healthcare costs and suicides. PCA scatterplots visually represented how exposure–outcome relationships clustered by household type, further underlining structural vulnerability. These visual tools did not merely confirm statistical associations but made the structural relationships vivid and intelligible.

Morbidity and mortality profiles observed in Kelapur illustrate a classic syndemic scenario, defined as the co-occurrence and interaction of multiple diseases that are linked by shared ecological and social determinants. Communicable diseases such as tuberculosis, diarrhoea, and malaria persist due to inadequate sanitation and fragile public health infrastructure. At the same time, non-communicable diseases, particularly cardiovascular conditions, cancers, and renal disorders, are on the rise as a direct result of pesticide exposure, dietary transitions, and stress. Genetic conditions, such as sickle cell anaemia, compound these risks, while reproductive losses—including miscarriages and stillbirths—reflect the intersection of chemical toxicity with chronic nutritional stress. Suicides and alcoholism emerge as another layer of social suffering, translating despair into mortality. These overlapping conditions reinforce one another, trapping households in cycles of ill health, debt, and despair. This aligns with Merrill Singer's concept of syndemics, where disease clustering is less about biological coincidence and more about the structural violence inherent in agrarian economies.

Gender remains central to patterns of exposure and outcomes. Men face direct occupational exposure through pesticide spraying and physical labour in fields. Consequently, they bear higher mortality rates from suicides, cancers, and cardiovascular diseases. Women, in contrast, are more likely to encounter indirect exposures through domestic pathways such as washing pesticide-soiled clothes or cooking with contaminated water. These exposures contribute to reproductive wastage, high anaemia prevalence, and a disproportionately high rate of early menopause. Children embody a third dimension of vulnerability: they suffer from infections, malnutrition, and developmental delays linked both to chemical exposure and poor diets. These patterns reflect not only gendered divisions of labour but also entrenched cultural expectations around marriage, fertility and care giving that deepen health risks across generations.

Consequences of agricultural modernisation extend across generations. Children inherit weakened nutritional foundations as dietary diversity declines and traditional millets are replaced with market-dependent grains. Adults, particularly those engaged in cotton and soybean farming, face direct occupational exposures that manifest as chronic disease later in life. Women are burdened with reproductive wastage and health complications that destabilise household demographics, while elders die with minimal care, their deaths often classified as "natural" even though they are rooted in untreated or preventable conditions. This intergenerational cycle illustrates how agricultural change does not merely affect one cohort but reshapes the trajectory of health and survival for the entire community. From the bio-cultural perspective, the health transition observed in Kelapur exemplifies how structural determinants such as agricultural policy, debt, and global markets intersect with cultural practices around marriage, fertility, and healing, as well as ecological factors like rain-fed farming and semi-arid soils, to produce a distinctive health profile. Health here is not reducible to categories of disease but is lived and experienced through suffering, resilience, and adaptation. The integration of quantitative epidemiology with ethnographic narratives makes clear that rural health in Vidarbha cannot be understood in isolation from the agricultural ecologies and socio-cultural transformations that frame daily life.

CONCLUSION

Findings of this study demonstrate unequivocally that the agricultural transformation in Vidarbha has produced a multi-layered health crisis among tribal farmers of Kelapur block. What initially began as a shift towards cash-crop cultivation in search of higher productivity has, over time, given rise to an epidemiological landscape dominated by non-communicable diseases, reproductive disorders, occupational hazards, and socio-psychological stress, while communicable diseases and malnutrition continues. Such duality reflects an incomplete epidemiological transition, where older risks have not disappeared but instead overlap with new vulnerabilities generated by agricultural modernization. Evidences confirm the dual burden of disease faced by these communities. Infectious diseases such as tuberculosis, malaria, and diarrhoea remain significant, underscoring poor sanitation and inadequate healthcare access. At the same time, non-communicable diseases including cardiovascular conditions, renal disorders, cancers, and respiratory illnesses now dominate morbidity and mortality, with clear links to pesticide exposure and lifestyle changes. This coexistence demonstrates that the health crisis is not linear but cumulative, with new risks layering upon old ones to create a compounded burden.

Reproductive health emerges as one of the most severe consequences of this transition. Women marry early, with the mean age at marriage being 19.1 years, and conceive early, with the mean age at first conception being 20.7 years. High levels of reproductive wastage are directly linked to pesticide exposure, while early menopause reported among 12.3 percent of women aged 30–44 years suggests endocrine disruption. These outcomes compromise not only women's health but also the stability of households and the demographic sustainability of the community.

Exposure pathways to pesticides and fertilizers are multi-dimensional, encompassing occupational exposures through spraying and mixing, domestic exposures through storage and washing, environmental exposures through soil, water, and air, and even cultural exposures through ritual spraying and barefoot agricultural labour. These exposures have been shown to be strongly associated with cardiovascular morbidity and mortality, renal and gastrointestinal disorders, reproductive wastage in the form of miscarriages, stillbirths, and early menopause, as well as cancers—particularly oral and gastrointestinal malignancies. Household proximity to stored chemicals highlights that even those not directly engaged in agricultural work, such as women, children, and elders, face considerable health risks.

Mortality data collected between 2015 and 2025 further reveal the complexity of transitions. Elderly natural deaths still dominate, accounting for 28.8 percent of deaths, but non-communicable diseases, including cardiovascular, renal, and cancer-related deaths, now constitute nearly one-third of total mortality. Unnatural deaths, at 12.3 percent, are primarily suicides among men and reflect the agrarian distress embedded in Vidarbha's cotton economy. Gendered mortality patterns are also evident, with men dominating deaths from suicides and cancers while women are more frequently represented in elderly natural deaths and reproductive complications. These patterns demonstrate that mortality reflects not only biomedical risks but also the structural violence inherent in the agricultural economy.

Patterns of health-seeking behaviour reflect pluralism but also precocity. Traditional healers continue to play a role in providing culturally meaningful care, yet their influence is in decline. Biomedical care available at Primary Health Centres and sub-district hospitals is hampered by staff shortages, unavailability of medicines, and frequent referral delays. In the face of these gaps, self-medication, home remedies, and faith-based healing fill the void, though often at the cost of delaying effective treatment. Alcoholism further complicates healthcare-seeking, particularly among men, who frequently postpone or refuse treatment due to intoxication. This pluralism illustrates resilience but simultaneously highlights systemic neglect of tribal healthcare needs.

Robustness of these findings is strengthened by statistical and epidemiological evidence. Bivariate and multivariate analyses consistently confirm strong associations between agro-chemical exposure and adverse health outcomes. Logistic regression models demonstrate that pesticide exposure doubles the odds of cardiovascular and renal morbidity. Cox proportional hazards models reveal elevated risks of cardiovascular and cancer mortality. Multinomial models show that pesticide exposure significantly increases the risks of miscarriage and stillbirth. PCA clustering illustrates that households with high exposure, particularly those cultivating cotton and soybean, carry disproportionate health burdens. These results are further supported by correlation matrices, heatmaps, and visual tools such as forest plots, which reinforce both the strength and clarity of associations. From a bio-cultural perspective, the study makes clear that agriculture in Vidarbha is not merely an economic process but also a cultural system whose transformation has reshaped diets, rituals, kinship, and ultimately resilience. Health outcomes represent a syndemic scenario, characterised by the simultaneous presence of infectious diseases, non-communicable diseases, genetic disorders, reproductive losses, and suicides, all driven by structural determinants. Gender roles structure the pathways of exposure and outcomes, with women bearing hidden reproductive costs and men more visible occupational and psychological burdens. At the core lies structural violence—manifest in global cotton markets, indebtedness, and policy neglect—that underpins suicides and chronic health burdens.

Study findings point to urgent policy implications. Agro-ecological shifts must be promoted through crop diversification, organic farming, and reductions in chemical use. Pesticide regulation, including the banning of highly hazardous chemicals and training of farmers in safe handling, is necessary to reduce exposure. Strengthening health infrastructure through consistent staffing, reliable drug supply, and mobile health units for remote villages is vital. Reproductive health programs should be expanded to include screening for early menopause, addressing anaemia, and improving maternal health outreach. Mental health support, debt relief mechanisms, and suicide prevention services are equally essential. At the same time, traditional healers must be recognised and integrated into health programs to bridge cultural gaps and improve trust.

This study contributes to both epidemiology and anthropology. From an epidemiological standpoint, it documents the rise of non-communicable diseases and reproductive losses in a high-input agricultural system. From an anthropological perspective, it demonstrates how structural and cultural factors intersect to create a bio-cultural health crisis. Methodologically, it underscores the importance of integrating statistical models with ethnographic insights, showing that numbers alone cannot capture the full spectrum of suffering and resilience.

Massive transformation of agriculture in Vidarbha has not only altered the landscape of fields but also reshaped the landscape of bodies, health, and society. Farmers who once relied on diverse crops and cultural resilience are now trapped in cycles of chemical dependence, debt, disease, and despair. Women carry the hidden reproductive costs, men endure the visible occupational and psychological burdens, and children inherit a compromised future. The conclusion is clear: agricultural modernisation in Kelapur has come at a grave cost to health and well-being. Addressing this crisis requires moving beyond yield and productivity toward a paradigm that prioritises human health, ecological sustainability, and cultural integrity.

INTERVENTION

Impact assessment of changing agricultural practices on rural health could not be understood properly in isolation of multi-dimensional facets of the core. Contextually it is the whole of a combition of "ecology/environment-community-practices" around the transformed mode of modern agricultural practices – where land, water, culture core, seed varieties, agro-chemicals, mechanization, production, economic viability and farmers' aspiration are the major components to deal with community health and environmental issues in order to address sustainability in agrarian societies.

Findings of this study highlight the urgent need for a policy intervention to address the multi-dimensional health crisis in Kelapur taluka and other intensified crop practice areas of Vidarbha region. Existing agricultural policies must look beyond profit based productivity to a sustainable agro-ecological framework, prioritizing human as well as environmental health with equal attentions. Crop diversification should be actively encouraged, with incentives for farmers to cultivate traditional food crops like cereals, pulses and fooders simultaneous to cash crops, assuring food and nutritional security among tribals with reduced/controlled dependencies on exotic food items and buffer against climate variability. Similarly, gradual reducing trends in maintaining cattle resources among tribal households, which once were the primary source for agricultural operations and effective organic manure, are now being replacing by machine-tools because of scarcity in locally grown fodders (*jowar* and other grass varieties), thus also juxtaposed to follow organic farming now-a-days in most of the studied villages. A clear policy of fodder cultivation either in the cultivable wasteland or some portion of total net-sown area that to be earmarked as buffer zone only for fodder grass should be adopted with insentive based fodder farming and/or co-operative fodder cultivation practices. Simultaneously organic farming practices and integrated pest management should be promoted to reduce pesticide dependency, thereby lowering health risks, eco-environmental degradations. In order to ensure livelihood of tribal households/villagers from own village or neighbouring areas – a pilot project of integrated agricultural practices in combination of pisciculture (in impressive rainfed areas), floriculture, poultry farming and cattle rearing may also be adopted, in addition to cotton and soybean cultivation in Kelapur taluka. There are marked gender discriminations in daily wage rates among farmworkers, which should be equal for all.

A policy should be adopted to regulate overdose use of chemical fertilizer and hazardous pesticides in crop fields, with strict enforcement mechanisms of rational sale/buy and application of agro-chemicals. Participation of local NGOs under patronage of state agricultural department (KVK or Agriculture Extension Office), pre-season mass-awarness programmes on adverse effect of careless handling of fertilizer-pesticides on farmers' health should be incorporated in the agricultural policies. Simultaneously training programmes on safe handling, mixing and storing of pesticides should be carried out in regular interval among farmers. Distribution of protective equipment/gear among farmers and its meaningful application methods must be well monitored by *gram-sevak*. Since exposure pathways extend beyond the field to home - participation of local college students in sensitizing villagers under sustainable agricultural practice programmes, thus to be adopted by district education department under compulsory college education carriculam. Policy of institutional support to farmers through better procurement systems, fair pricing mechanisms for cotton and soybean and access to affordable credit must also strengthen thereby alleviating the economic pressures that contribute to agrarian distress and suicides in this area.

Ensuring least health hazard, framing of a very specific health-care policy earmarked to farmworkers is equally important. Strengthening the exisiting primary health-care system through adequate staffing, sufficient drug supplies and regular outreach programme can mitigate both communicable and non-communicable disease burdens. Mobile health units, particularly for remote villages should ensure for timely diagnosis and treatment of pesticide poisoning, maternal health complications and associated chronic conditions. During peak agricultural season, mobile health units should make a compulsory visit to each village for carrying out healthcamp in ascertaining the nature of illness and severity among farmer households. Reproductive health must be a priority in monitoring delayed age of menarche and early menopause and to address nutritional anaemia and/or occupational hazards through clinical interventions. Integrating mental health services, including counselling and suicide prevention programmes is also to be essentially addressed circumstantial to indebtedness, crop failure and agro-chemical exposure-related chronic illness.

Finally, cultural sensitivity must be embedded within policy design. Traditional healers need to be inducted in the service delivery component at villages, while farmers mostly neglect consulting doctors/PHC for primary level healing discomports due to agro-chemical exposures. They should be oriented with the cause and effects of ago-chemicals pertaining proper training. Such integration would not only enhance trust on the healthcare system but also bridge the gap between cultural worldviews and bio-medical interventions. At the same time, inter-generational knowledge of indigenous seeds, food habits and traditional way of ecology conservation practices should be revamped and revitalised through community seed banks, farmer cooperatives and school-based awareness initiatives. Some other urgent welfare measures such as compensasion of temporary or permanent vision loss due to agro-chemical exposure and wage protection during consultation of PHC and/or under medication state because of agro-chemical exposures must cover under essential farmers' friendly agricultural policy. An earmarked health policy (Kishan Swasthya Bima) for farmer may be adopted In view of multi-dimensional facets of intensified agricultural practices - a state own Consortium (integration of District Agriculture Department-District Referal Hospital-District Education Department-NGOs-community leaders-state based Research centres of national repute) need to be constituted in framimg a viable Integrated Agricultural Policy and monitoring sustainable agricultural practices in agricultural (both tribal and non-tribal) villages of Vidarbha region. A full-fledged functional regulatory authority only could mitigate urgent issues related to occupational (cultivation) health hazards (physical as well as psychological) and environmental degradation and also to create a pathway towards a true sustainable, equitable and culturally grounded agricultural system in the Vidarbha region of Maharasthra.

BIBLIOGRAPHY

Agresti, A. (2018). *An introduction to categorical data analysis* (3rd ed.). Wiley.

Amizadeh, M., Safari-Kamalabadi, M., Askari-Saryazdi, G., Amizadeh, M., & Reihani-Kermani, H. (2017). Pesticide exposure and head and neck cancers: a case-control study in an agricultural region. *Iranian Journal of Otorhinolaryngology*, *29*(94), 275.

Ashwani, & Singh, C. (2023).Statistical Analysis of the map-based Sensitive Health issues in Vidarbha region, Maharashtra. *Indiana Journal of Agriculture and Life Sciences, 3*(1), 1-6.

Ataei, M., & Abdollahi, M. (2022). A systematic review of mechanistic studies on the relationship between pesticide exposure and cancer induction. *Toxicology and applied pharmacology*, *456*, 116280. https://doi.org/10.1016/j.taap.2022.116280

ATMA-Yavatmal. (2023). *Strategic Research and Extension Plan (SREP), Yavatmal District*. Government of Maharashtra.

Behere, P. B., & Behere, A. P. (2008). Farmers' suicide in Vidarbha region of Maharashtra state: A myth or reality?. *Indian journal of psychiatry*, *50*(2), 124–127. https://doi.org/10.4103/0019-5545.42401

Behera, S., & Kumbhar, R. K. (2023). *Tribal health care in India: A systematic review of practices and beliefs*. *International Research Journal of Social Sciences, 12*(3), 61–67

Bhukya, B. (2010). Subjugated nomads: The Lambadas under the rule of the Nizams. Orient Blackswan

Joshi, K. P., Bindu, M. H., & Jamadar, D. (2023). Demographic & health profile of tribal population of Telangana-A cross sectional study. *The Journal of Community Health Management*, *9*(3), 120-125.

Boedeker, W., Watts, M., Clausing, P., & Marquez, E. (2020). RETRACTED ARTICLE: The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. *BMC public health*, *20*(1), 1875.

Bomble, P., & Lhungdim, H. (2020). Mental health status of Farmers in Maharashtra, India: A study from farmer suicide prone area of Vidarbha region. *Clinical epidemiology and global health*, *8*(3), 684-688.

Census of India. (2011). *Primary Census Abstract, Maharashtra*. Office of the Registrar General and Census Commissioner, Government of India.

Census of India. (2011). *Village and town directory: Yavatmal district handbook*. Directorate of Census Operations, Maharashtra.

Census of India, 2011. Yavatmal District Primary Census Abstract. Agriculture Census 2015-16, Maharashtra. Area Operated by Social Groups and Landholding Sizes. https://agcensus.nic.in

Chakma, T., Kavishwar, A., Sharma, R. K., & Rao, P. V. (2017). High prevalence of hypertension and its selected risk factors among adult tribal population in Central India. *Pathogens and global health*, *111*(7), 343–350. https://doi.org/10.1080/20477724.2017.1396411

Chaudhry, D. (2022). Pesticide Use in Indian Agriculture: Policy Alternatives for Environmental Health. *Journal of Development Policy and Practice*, *9*(1), 133-161. https://doi.org/10.1177/24551333221121890

Chourasia, M., Raghavendra, K., Bhatt, R., Swain, D., Valecha, N., & Kleinschmidt, I. (2017). *Burden of asymptomatic malaria among a tribal population in a forested village of central India: A hidden challenge for malaria control in India*. *Public Health, 147*, 92–97. https://doi.org/10.1016/j.puhe.2017.02.010

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Routledge.

Colah, R. B., Mukherjee, M. B., Martin, S., & Ghosh, K. (2015). Sickle cell disease in tribal populations in India. *The Indian journal of medical research*, *141*(5), 509–515. https://doi.org/10.4103/0971-5916.159492

Cotton Corporation of India. (2021). *Area, production, and productivity of cotton in India*. https://cotcorp.org.in/statistics.aspx

Curl, C. L., Spivak, M., Phinney, R., & Montrose, L. (2020). Synthetic Pesticides and Health in Vulnerable Populations: Agricultural Workers. *Current environmental health reports*, *7*(1), 13–29. https://doi.org/10.1007/s40572-020-00266-5

Deshmukh, V. D., Patil, P. G., & Bhagat, R. B. (2021). Prevalence and risk factors of hypertension in tribal populations: A cross-sectional study from central India. *Indian Journal of Public Health, 65*(1), 42–46.

Venugopal, D., & Ravichandran, B. (2018). *Occupational health risk of farmers exposed to pesticides in agricultural activities*. *Current Opinion in Environmental Science & Health, 4*, 31–37. https://doi.org/10.1016/j.coesh.2018.07.005

District Agriculture Office, Yavatmal(2018) (via DIP and DAP reports). Land use patterns and cropping intensity.

Dongre, A. R., & Deshmukh, P. R. (2012). Farmers' suicides in the Vidarbha region of Maharashtra, India: a qualitative exploration of their causes. *Journal of Injury and Violence research*, *4*(1), 2.

Elwin, V. (1947). *The Gonds of Central India*. Oxford University Press.

Elwin, V. (1959). *The tribal art of Middle India*. Oxford University Press.

Expert Committee on Tribal Health. (2014). Tribal health in India: Bridging the gap and a roadmap for the future - Executive summary. Ministry of Health & Family Welfare & Ministry of Tribal Affairs, Government of India.

Fareed, M., Pathak, M. K., Bihari, V., Kamal, R., Srivastava, A. K., & Kesavachandran, C. N. (2013). Adverse respiratory health and hematological alterations among agricultural workers occupationally exposed to organophosphate pesticides: a cross-sectional study in North India. *PloS one*, *8*(7), e69755.

Gadgil, S., & Gadgil, S. (2006). The Indian monsoon, GDP and agriculture. *Economic and political weekly*, 4887-4895.

Ghosh, K., Colah, R. B., & Mukherjee, M. B. (2015). Haemoglobinopathies in tribal populations of India. *The Indian journal of medical research*, *141*(5), 505–508. https://doi.org/10.4103/0971-5916.159488

Goodman, A. H., & Leatherman, T. L. (Eds.). (1998). *Building a new biocultural synthesis: Political-economic perspectives on human biology*. University of Michigan Press. https://press.umich.edu/Books/B/Building-a-New-Biocultural-Synthesis

Gorakshakar, A. C. (2006). Epidemiology of sickle haemoglobin in India.ICMR-NIRTH

Government of India. (2019). *Press Information Bureau, Ministry of Agriculture & Farmers Welfare*. https://pib.gov.in

Government of India. (2023). *Annual Report 2022–23*. Ministry of Statistics and Programme Implementation.

Government of Maharashtra. (2024). *Economic Survey of Maharashtra 2023–24*. Directorate of Economics and Statistics, Planning Department. https://mahades.maharashtra.gov.in/

Government of India. (2024). *Periodic Labour Force Survey (PLFS) 2023–24: Annual report*. Ministry of Statistics and Programme Implementation.

Government of India. (2019) . Press Information Bureau. Ministry of Agriculture & Farmers Welfare. https://www.pib.gov.in

Government of Maharashtra. (2020–21). *Strategic Research & Extension Plan (SREP), Yavatmal District*. Department of Agriculture, World Bank-assisted NDKSP Project.

Government of Maharashtra. (2022). *Soil health card and irrigation statistics – Yavatmal district*. Department of Agriculture.

Government of Maharashtra. (2024). *Economic survey of Maharashtra 2023–24*. Directorate of Economics and Statistics. https://mahades.maharashtra.gov.in

Gureje, O., Nortje, G., Makanjuola, V., Oladeji, B., Seedat, S., & Jenkins, R. (2015). The role of global traditional and complementary systems of medicine in treating mental health problems. *The lancet. Psychiatry*, *2*(2), 168–177. https://doi.org/10.1016/S2215-0366(15)00013-9.

Hazra, D. (1983). The Kolam of Yeotmal. Anthropological Survey of India

Hosmer, D. W. (2002). Applied survival analysis; regression modeling of time to event data. Wiley-Interscience

Rao, C. S., Rao, K. V., Chary, G. R., Prasad, Y. G., Subba Rao, A. V. M., Ramana, D. B. V., ... & Sikka, A. K. (2015). compensatory Rabi production Plan-2015. *Technical bulletin*, *1*, 2015.

IIPS & MoHFW. (2021). National Family Health Survey (NFHS-5), 2019–21: Maharashtra district fact sheets. International Institute for Population Sciences.

International Institute for Population Sciences (IIPS) & ICF. (2021). National Family Health Survey (NFHS-5), 2019–21: India. IIPS.

Jadhav, N. (2019). Health vulnerabilities and socio-economic stress among tribal women farmers in Maharashtra. Journal of Rural Development Studies, 36(2), 45–61.

Jain, Y., Kataria, R., Patil, S., Kadam, S., Kataria, A., Jain, R., Kurbude, R., & Shinde, S. (2015). Burden & pattern of illnesses among the tribal communities in central India : A report from a community health programme. *The Indian journal of medical research*, *141*(5), 663–672. https://doi.org/10.4103/0971-5916.159582

Jayatilake, N., Mendis, S., Maheepala, P., & Mehta, F. R. (2013). *Chronic kidney disease of uncertain aetiology: Prevalence and causative factors in a developing country*. *BMC Nephrology, 14*(1), 180. https://doi.org/10.1186/1471-2369-14-180

Jolliffe, I. T., & Cadima, J. (2016). *Principal component analysis: A review and recent developments*. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 374*(2065), 20150202. https://doi.org/10.1098/rsta.2015.0202

Kamarapu, R. C., Kumar, R., & National Institute of Health and Family Welfare. (2020). *Health status of tribal women of Bhadradri Kothagudem District in Telangana state*. *International Journal of Health Sciences and Research, 10*(1), 53–54

Kaur, P., Borah, P. K., Uike, P. V., Mohapatra, P. K., Das, N. K., Gaigaware, P., Tobgay, K. J., Tushi, A., Zorinsangi, Mazumdar, G., Marak, B., Pizi, D., Chakma, T., Sugunan, A.

P., Vijayachari, P., Bhardwaj, R. R., Arambam, P. C., Kutum, T., Sharma, A., … Mehendale, S. M. (2022). *Non-communicable diseases as a major contributor to deaths in 12 tribal districts in India*. *Indian Journal of Medical Research, 156*(2), 250–259. https://doi.org/10.4103/ijmr.ijmr_3332_21

Kennedy, J., & King, L. (2014). *The political economy of farmers' suicides in India: Indebted cash-crop farmers with marginal landholdings explain state-level variation in suicide rates*. *Globalization and Health, 10*(1), 16. https://doi.org/10.1186/1744-8603-10-16

Khode, D., Hepat, A., Mudey, A., & Joshi, A. (2024). Health-related challenges and programs among agriculture workers: a narrative review. *Cureus*, *16*(3).

Kirkwood, B. R., & Sterne, J. A. (2010). *Essential medical statistics*. John wiley & sons.

Kleinman, A. (1980). *Patients and healers in the context of culture: An exploration of the borderland between anthropology, medicine, and psychiatry* (Vol. 3). Univ of California Press.

Kranthi, K. R., Jadhav, D. R., Kranthi, S., Wanjari, R. R., Ali, S. S., & Russell, D. A. (2002). Insecticide resistance in five major insect pests of cotton in India. *Crop protection*, *21*(6), 449-460.

Kshatriya, G. K., & Acharya, S. K. (2016). Triple burden of obesity, undernutrition, and cardiovascular disease risk among Indian tribes. *PloS one*, *11*(1), e0147934.

Kulkarni, R., Surve, S., Patil, S., Sankhe, L., Gupta, P., & Toteja, G. (2019). Nutritional status of adolescent girls in tribal blocks of Maharashtra. *Indian Journal of Community Medicine*, *44*(3), 281-284.

Kulkarni, P., Kulkarni, P.,&Indiaspend. (2018, October 20). Indiaspend.

Kumar, V., & Jain, S. (2023). Landscape analysis of traditional tribal healers and their healing practices in the tribal-dominated states of India.

Kunjumon, A., Nagarajan, S., Thodukayil, F. S. O., & Panneer, S. (2024). Factors associated with under-five mortality in Scheduled Tribes in India: An analysis of national family health survey-5 (2019-2021). *The Indian Journal of Medical Research*, *160*(1), 31.

Kuppusamy, P., Prusty, R. K., Chaaithanya, I. K., Gajbhiye, R. K., & Sachdeva, G. (2023). Pregnancy outcomes among Indian women: increased prevalence of miscarriage and stillbirth during 2015–2021. *BMC Pregnancy and Childbirth*, *23*(1), 150.

Laxmaiah, A., Meshram, I. I., Arlappa, N., Balakrishna, N., Rao, K. M., Reddy, C. G., ... & Brahmam, G. N. V. (2015). Socio-economic & demographic determinants of hypertension & knowledge, practices & risk behaviour of tribals in India. *Indian Journal of Medical Research*, *141*(5), 697-708.

Lerche, J. (2014). Regional patterns of agrarian accumulation in India 1. In *Indian capitalism in development* (pp. 46-65). Routledge.

Linda, A. I., Pal, D., Murmu, N., & Taywade, M. (2024). Health of tribal population in India: a glimpse of the current scenario. *Current Medical Issues*, *22*(2), 114-117.

Long, J. S., & Freese, J. (2006). *Regression models for categorical dependent variables using Stata* (Vol. 7). Stata press.

Marques, B., Freeman, C., & Carter, L. (2021). Adapting traditional healing values and beliefs into therapeutic cultural environments for health and well-being. *International journal of environmental research and public health*, *19*(1), 426.

Mehta, A. (2015). Pesticide poisoning and its management. Indian Journal of Medical Specialities, 6(4), 161–164. https://doi.org/10.1016/j.injms.2015.07.005

Meshram, I. I., Laxmaiah, A., Mallikharjun, R. K., Arlappa, N., Balkrishna, N., & Reddy, C. G. (2014). Prevalence of hypertension and its correlates among adult tribal population (≥ 20 years) of Maharashtra State, India. *Int J Health Sci Res*, *4*(1), 130-9.

Ministry of Health & Family Welfare; Ministry of Tribal Affairs, Government of India. (2018). Report of the Expert Committee on Tribal Health: Tribal health in India-Bridging the gap and a roadmap for the future. New Delhi: Government of India.

Purty, A. J., Mishra, A. K., Chauhan, R. C., Prahankumar, R., Stalin, P., & Bazroy, J. (2019). Burden of pulmonary tuberculosis among tribal population: A cross-sectional study in tribal areas of Maharashtra, India. *Indian journal of community medicine*, *44*(1), 17-20.

Mittal, N., Steinert, J. I., & Vollmer, S. (2023). COVID-19 pandemic, losses of livelihoods and uneven recovery in Pune, India. *Humanities and Social Sciences Communications*, *10*(1), 1-10.

Mondal, S., & Bhattacharya, S. (2023). Tribal Medicine of India: an evolving ancient tradition. *The ESRF Research Journal for Undergraduate Medical Students*, *1*(1 (Jul-Dec)), 3-5.

Ministry of Social Justice & Empowerment. (2018). Status Report on Denotified, Nomadic and Semi-Nomadic Tribes. Government of India.

NABARD. (2018). *NABARD All India Rural Financial Inclusion Survey 2016–17 (NAFIS)*. National Bank for Agriculture and Rural Development.

Narain, J. P. (2022). India at 75: transforming the health of tribal populations through evidence-based policymaking. *Indian Journal of Medical Research*, *156*(2), 174-178.

Narain, J. P. (2019). Health of tribal populations in India: How long can we afford to neglect?. *Indian Journal of Medical Research*, *149*(3), 313-316.

Narain, J. P. (2022). India at 75: transforming the health of tribal populations through evidence-based policymaking. *Indian Journal of Medical Research*, *156*(2), 174-178.

National Family Health Survey (NFHS-5). (2021). *India Fact Sheet*. International Institute for Population Sciences (IIPS).

National Health Systems Resource Centre (NHSRCM). (2023). National Sickle Cell Anaemia Elimination Mission. Ministry of Health and Family Welfare, Government of India.

National Sample Survey Office (NSSO). (2014). *Key Indicators of Household Consumer Expenditure in India: NSS 68th Round (2011–12)*. Ministry of Statistics and Programme Implementation, Government of India.

Office of the Registrar General & Census Commissioner, India. 2023. Sample Registration System Statistical Report 2021. New Delhi: Ministry of Home Affairs, Government of India.

Rao, P., Raj, E. A., Natesan, S., & Gudi, N. (2024). Prevalence of Sickle cell disease, Sickle cell trait and HBS-beta-thalassemia in India: A systematic review and Meta-analysis. *Clinical Epidemiology and Global Health*, *28*, 101678.

Rao, V. G., Bhat, J., Yadav, R., Muniyandi, M., Sharma, R., & Bhondeley, M. K. (2015). Pulmonary tuberculosis-a health problem amongst Saharia tribe in Madhya Pradesh. *Indian Journal of Medical Research*, *141*(5), 630-635.

Rathod, K. B., Tijare, J.,& Department of Pathology, Government Medical College, India. (2017). Ethnicity of sickle cell anaemia: Study at Tertiary Care Hospital of Yavatmal. In International Research Journal of Medicine and Medical Sciences (Vols. 5–4, pp. 64–68).

Mittal, S. (2006). Agricultural productivity trends in India: Sustainability issues. *Agricultural Economics Research Review*. https://doi.org/10.5958/0974-0279.2020.00003.5

Rivero, A., Vezilier, J., Weill, M., Read, A. F., & Gandon, S. (2010). Insecticide control of vector-borne diseases: when is insecticide resistance a problem?. *PLoS pathogens*, *6*(8), e1001000.

Rupa, D. S., Reddy, P. P., & Reddi, O. S. (1991). Reproductive performance in population exposed to pesticides in cotton fields in India. *Environmental research*, *55*(2), 123-128.

Sahu, M., Kujur, A., Venugopal, V., Govil, P., Sinha, R., Mathur, M., ... & Kumar, D. (2024). Tribal Health: A Public Health Exigency and Road Map to Future. *Indian Journal of Community Medicine*, *49*(Suppl 2), S217-S221.

Sanket Jain. (2024). In India, climate change drives pesticide use, harming farmers health | Think Global Health. (2024, July 18). Think Global Health.

Sathiyanarayanan, S., Muthunarayanan, L., & Devaparthasarathy, T. A. (2019). Changing perspectives in tribal health: Rising prevalence of lifestyle diseases among tribal population in India. *Indian Journal of Community Medicine*, *44*(4), 342-346.

Sekhotha, M. M., Monyeki, K. D., & Sibuyi, M. E. (2016). Exposure to agrochemicals and cardiovascular disease: a review. *International journal of environmental research and public health*, *13*(2), 229.

Sharma, B. D. (Ed.). (2004). The Royal People of India: Maharashtra (Vol. XXX, Parts I & II). Anthropological Survey of India, University of Calcutta: Seagull Books.

Sharma, R. K., Thakor, H. G., Saha, K. B., Sonal, G. S., Dhariwal, A. C., & Singh, N. (2015). Malaria situation in India with special reference to tribal areas. *Indian Journal of Medical Research*, *141*(5), 537-545.

Shekhar, C., Khosya, R., Thakur, K., Mahajan, D., Kumar, R., Kumar, S., & Sharma, A. K. (2024). A systematic review of pesticide exposure, associated risks, and long-term human health impacts. *Toxicology Reports*, 101840.

Singh, M., Shekhar, C., & Shri, N. (2023). Patterns in age at first marriage and its determinants in India: A historical perspective of last 30 years (1992–2021). *SSM-population health*, *22*, 101363.

Singh, S. (2012). Pesticide exposure and health risks among farmers in India: A review. Journal of Agricultural Science and Technology A, 2(5A), 603–612.

Subramanian, S. V., & Joe, W. (2024). Population, health and nutrition profile of the Scheduled Tribes in India: a comparative perspective, 2016–2021. *The Lancet Regional Health-Southeast Asia*, *20*.

Swaminathan, M. S., Rawal, V., & Ramachandran, V. K. (2020). *Farmers' Distress in India: Findings from a Nationwide Survey*. *Social Scientist, 48*(3/4), 3–26.

Uikey, A. A., & Patil, S. (2023). Socioeconomics influencing pesticide management practices in the tribal area of Maharashtra. *Current Agriculture Research Journal*, *11*(3), 928-939.

Vasishtha, G., Mohanty, S. K., Mishra, U. S., Dubey, M., & Sahoo, U. (2021). Impact of COVID-19 infection on life expectancy, premature mortality, and DALY in Maharashtra, India. *BMC infectious diseases*, *21*(1), 343.

Vennam, B. S. V., Kuppli, S. S., Kumar Bora, J., Sahoo, S. S., Gujjarlapudi, C., Bhimarasetty, D. M., ... & Goel, S. (2024). Socioeconomic and behavioral factors of hypertension among Indian tribal population: Evidence from national family health survey 5. *Plos one*, *19*(12), e0312729.

Verma, A. K., Shrivastava, S., & Saxena, N. (2025). Malaria and malnutrition in tribal areas of India: implications for paediatric health. *Frontiers in Gastroenterology*, *4*, 1526806.

Wagh, R., & Dongre, A. P. (2016). Agricultural sector: status, challenges and it's role in Indian economy. *Journal of Commerce and Management Thought*, *7*(2), 209.

Kori, R. K., Thakur, R. S., Kumar, R., & Yadav, R. S. (2018). Assessment of adverse health effects among chronic pesticide-exposed farm workers in Sagar District of Madhya Pradesh, India. *International Journal of Nutrition, Pharmacology, Neurological Diseases*, *8*(4), 153-161.

Yadav, S., & Arokiasamy, P. (2014). Understanding epidemiological transition in India. *Global health action*, *7*(1), 23248.

Yadav, S., Yadav, P. K., & Yadav, N. (2021). Impact of COVID-19 on life expectancy at birth in India: a decomposition analysis. *BMC Public Health*, *21*(1), 1906.

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APPENDIX I

PROFILES OF VILLAGES

Introduction

This appendix documents the baseline characteristics of 25 villages of Kelapur Taluka, Yavatmal District, Maharashtra that constitute the study area for investigating the epidemiological impact of changing agricultural trends on tribal health.

The selected villages represent the diversity of tribal settlements in Kelapur Taluka in which traditional agriculture systems have attained various degrees of modernization. Information on population composition, health infrastructure and community status of these villages for interpretation of data on health outcomes.

Administrative Classification and Geographic Distribution

Table 1: Administrative Framework and Geographic Coordinates

Sr. No.	Village Name	Geographic Coordinates	Revenue Jurisdiction	Gram Panchayat	Distance from Taluka HQ (km)	Distance from District HQ (km)
1	Mangurda	20º2’17.48” N, 78º35’24.81” E	Mangurda	Mangurda	5	75
2	Wai	20º4’52.20” N, 78º37’52.77” E	Wai	Wai	14	80
3	Ganeshpur	20º1’23.16” N, 78º32’14.58” E	Wai	Padha	13	70
4	Dhoki	20º6’18.12” N, 78º37’42.06” E	Wai	Mangi	15	80
5	Munzala	20º11’7.11” N, 78º38’10.45” E	Munjhala	Munjala	25	110
6	Wanjari	19º56’22.43” N, 78º34’12.61” E	Wanjari	Wanjari	10	85
7	Zuli	20º 0’8.20” N, 78º26’18.32” E	Jhuli	Zuli	14	75
8	Both	19º57’55.02” N, 78º27’44.02” E	Both	Both	13	75
9	Niljai	20º5’7.99” N, 78º34’8.74” E	Khairgaon Budruk	Sakra	7	65
10	Ballarpur	19º56’23.79” N, 78º32’58.38” E	Chalbardi	Sakra Budruk	13	87
11	Khairgaon Deshmukh	20º 4’23.52” N, 78º 28’59.93” E	Khairgaon Deshmukh	Khairgaon Deshmukh	10	60
12	Sakhi Budruk	20º7’14.70” N, 78º34’22.55” E	Kinhala	Sakhi Budruk	13	68
13	Karegaon Rampur	20º11’29.65” N, 78º29’9.71” E	Karegaon Rampur	Karegaon Rampur	22	46
14	Tembhi	19º56’14.22” N, 78º30’56.09” E	Sunna	Tembhi	13	95
15	Wadvat	19º50’31.73” N, 78º28’50.53” E	Karegaon Bandal	Gubdi	48	90
16	Karegaon Bandal	20º11’29.65” N, 78º29’9.71” E	Karegaon Bandal	Karegaon Bandal	45	80
17	Khairi	19º50’23.64” N, 78º30’47.48” E	Chanakha	Rudha	35	80
18	Wathoda	20º10’17.98” N, 78º34’19.11” E	Wathoda	Wathoda	30	60
19	Tadumari	20º0’20.91” N, 78º34’7.40” E	Borgaon	Tadumari	5	75
20	Asoli	20º0’20.91” N, 78º34’7.40” E	Karegaon Rampur	Asoli	38	43
21	Dabha (Mankar)	20º10’9.43” N, 78º31’3.72” E	Wathoda	Dabha	18	65
22	Chikaldara	20º13’26.34” N, 78º29’57.07” E	Chikaldara	Chikaldara	40	50

23	Sakhara Budruk	20º5’59.65” N, 78º34’11.82” E	Chalbardi	Sakhra Budruk	10	85
24	Dariyapur	19º52’6.47” N, 78º27’36.74” E	Karegaon Bandal	Maregaon-2	60	89
25	Gopalpur	19º58’20.77” N, 78º36’11.38” E	Akoli Budruk	Akoli Budruk	9	75

Studied villages are distributed over Kelapur Taluka between 19º50'N to 20º13'N latitude and 78º26’E to 78º38’E longitude spanning approximately 47 kilometres north-south and 22 kilometres east-west in the tropical semi-arid Vidarbha region.

Administrative distances differ greatly. Villages are 5 km to 60 km from Taluka headquarters and 43 km to 110 km from district headquarters. The distances have implications for access to government services and administrative connectivity, though their significance is moderated by the availability of other modes of governance.

Villages are distributed across 15 varied revenue jurisdictions, reflecting the organization of rural settlements of the research area. The distribution also reflects the revenue administration, land record maintenance, and coordination of developmental programs in the research villages.

Demographics and Household Structure

Table 2: Village-wise Demographic Profile

Village Name	Total Population	Male	Female	ST	ST %	SC	SC %	Total HH	Avg HH Size
Mangurda	1,948	971	977	1,729	88.80%	0	0.00%	407	4.8
Wai	1,063	556	507	580	54.60%	125	11.80%	212	5
Ganeshpur	622	316	306	487	78.30%	113	18.20%	167	3.7
Dhoki	596	302	294	383	64.30%	0	0.00%	136	4.4
Munzala	1,261	622	639	1,024	81.20%	0	0.00%	261	4.8
Wanjari	1,389	684	705	717	51.60%	37	2.70%	358	3.9
Zuli	1,177	645	532	978	83.10%	0	0.00%	267	4.4
Both	2,119	1,081	1,038	1,440	67.90%	67	3.20%	520	4.1
Niljai	440	226	214	440	100.00%	0	0.00%	95	4.6
Ballarpur	387	189	198	305	78.80%	0	0.00%	100	3.9
Khairgaon Deshmukh	1,600	755	845	816	51.00%	0	0.00%	267	6.0
Sakhi Budruk	982	477	505	565	57.50%	17	1.70%	221	4.4
Karegaon Rampur	1,050	422	628	406	38.70%	16	1.50%	332	3.2
Tembhi	912	475	437	615	67.40%	0	0.00%	236	3.9
Wadvat	372	189	183	356	95.70%	0	0.00%	103	3.6
Karegaon Bandal	901	444	457	713	79.10%	0	0.00%	210	4.3
Khairi	532	240	292	355	66.70%	0	0.00%	90	5.9
Wathoda	1,037	527	510	708	68.30%	11	1.10%	278	3.7
Tadumari	1,110	524	586	513	46.20%	3	0.30%	274	4.1
Asoli	1,121	617	504	412	36.80%	0	0.00%	243	4.6
Dabha (Mankar)	849	426	423	634	74.70%	0	0.00%	180	4.7
Chikaldara	698	369	329	413	59.20%	0	0.00%	187	3.7
Sakhara Budruk	381	183	198	368	96.60%	0	0.00%	97	3.9
Dariyapur	340	173	167	333	97.90%	0	0.00%	89	3.8
Gopalpur	1,319	661	658	592	44.90%	205	15.50%	288	4.6
TOTAL	**24,206**	**12,340**	**11,866**	**15,882**	**65.60%**	**594**	**2.50%**	**5,618**	**4.3**

The study encompasses 24,206 participants over 5,618 households in 25 villages. Scheduled Tribes make up 65.6% (15,882 individuals) of the population, well above Maharashtra's state average of 9.4% and making this region largely tribal in nature. This density provides an appropriate base population for health trend studies characteristic of tribal populations. Village size ranges widely, from 340 inhabitants in Dariyapur to 2,119 for both. The distribution of sizes affects community organization, resource availability, and service provision patterns. Larger villages typically have more developed infrastructure but add more pressure on available resources, while the smaller villages will possess stronger traditional practices but will find it difficult to access proper facilities and services. The rural gender ratio of 962 females for every 1,000 males is above both the rural Maharashtra average of 929 and the rural national average of 947 and indicates relatively good demographic conditions. There is, however, considerable variation between villages, from 825 females per 1,000 males in Zuli to 1,217 in Khairi. Such variations can be due to several patterns of migration, economic factors, and health determinants of a cultural nature impinging on agricultural participation and health indicators. The household size varies from 3.2 members in Karegaon Rampur to 6.0 members in Khairgaon Deshmukh. The large households are more likely to represent traditional joint family arrangements with multiple generations residing together and pooling resources and experiences, whereas the small households may indicate economic strain driving the family towards fragmentation or out-migration for employment opportunities. These variations in household structure have implications for the availability of labour for farming, health-seeking behaviours, and economic capacity for healthcare expenditure.

Community Composition and Social Structure

Table 3: Complete Tribal and Caste Community Distribution

Village Name	Total HH	Gond (%)	Kolam (%)	Pardhan (%)	Mahadeo Koli (%)	Mana (%)	Kunbi (%)	Mahar (SC) (%)	Others (%)
Mangurda	407	152 (37.3%)	180 (44.2%)	6 (1.5%)	0 (0%)	0 (0%)	8 (2%)	0 (0%)	61 (15%)
Wai	212	90 (42.5%)	29 (13.7%)	16 (7.5%)	0 (0%)	1 (0.5%)	3 (1.4%)	33 (15.6%)	40 (18.9%)
Ganeshpur	167	50 (29.9%)	25 (15%)	10 (6%)	0 (0%)	0 (0%)	4 (2.4%)	25 (15%)	53 (31.7%)
Dhoki	136	31 (22.8%)	42 (30.9%)	13 (9.6%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	50 (36.8%)
Munzala	261	48 (18.4%)	112 (42.9%)	36 (13.8%)	0 (0%)	0 (0%)	63 (24.1%)	0 (0%)	2 (0.8%)
Wanjari	358	80 (22.3%)	106 (29.6%)	11 (3.1%)	0 (0%)	0 (0%)	8 (2.2%)	0 (0%)	153 (42.7%)
Zuli	267	126 (47.2%)	80 (30%)	13 (4.9%)	0 (0%)	0 (0%)	15 (5.6%)	0 (0%)	33 (12.4%)
Both	520	233 (44.8%)	45 (8.7%)	89 (17.1%)	0 (0%)	0 (0%)	55 (10.6%)	0 (0%)	98 (18.8%)
Niljai	95	80 (84.2%)	0 (0%)	15 (15.8%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ballarpur	100	71 (71%)	0 (0%)	13 (13%)	0 (0%)	0 (0%)	2 (2%)	0 (0%)	14 (14%)
Khairgaon Deshmukh	267	205 (76.8%)	35 (13.1%)	20 (7.5%)	0 (0%)	0 (0%)	4 (1.5%)	0 (0%)	3 (1.1%)
Sakhi Budruk	221	15 (6.8%)	110 (49.8%)	12 (5.4%)	0 (0%)	10 (4.5%)	70 (31.7%)	0 (0%)	14 (6.3%)
Karegaon Rampur	332	134 (40.4%)	20 (6%)	10 (3%)	0 (0%)	0 (0%)	98 (29.5%)	0 (0%)	70 (21.1%)
Tembhi	236	144 (61%)	0 (0%)	18 (7.6%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	74 (31.4%)
Wadvat	103	50 (48.5%)	29 (28.2%)	17 (16.5%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	7 (6.8%)
Karegaon Bandal	210	153 (72.9%)	0 (0%)	11 (5.2%)	7 (3.3%)	0 (0%)	9 (4.3%)	0 (0%)	30 (14.3%)
Khairi	90	14 (15.6%)	76 (84.4%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Wathoda	278	90 (32.4%)	88 (31.7%)	4 (1.4%)	0 (0%)	20 (7.2%)	11 (4%)	0 (0%)	65 (23.4%)
Tadumari	274	38 (13.9%)	4 (1.5%)	82 (29.9%)	0 (0%)	0 (0%)	29 (10.6%)	0 (0%)	121 (44.2%)
Asoli	243	100 (41.2%)	0 (0%)	16 (6.6%)	0 (0%)	0 (0%)	25 (10.3%)	0 (0%)	102 (42%)
Dabha (Mankar)	180	83 (46.1%)	21 (11.7%)	33 (18.3%)	0 (0%)	0 (0%)	6 (3.3%)	0 (0%)	37 (20.6%)
Chikaldara	187	20 (10.7%)	81 (43.3%)	11 (5.9%)	0 (0%)	22 (11.8%)	31 (16.6%)	0 (0%)	22 (11.8%)
Sakhara Budruk	97	87 (89.7%)	0 (0%)	5 (5.2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	5 (5.2%)
Dariyapur	89	78 (87.6%)	0 (0%)	10 (11.2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (1.1%)
Gopalpur	288	50 (17.4%)	64 (22.2%)	24 (8.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	150 (52.1%)

TOTAL	**5,618**	2222 (39.6%)	1147 (20.4%)	495 (8.8%)	7 (0.1%)	53 (0.9%)	441 (7.8%)	58 (1%)	**1195 (21.3%)**

The tribal community pattern shows unique settlement and social organization patterns. Gond households are the most populous single community at 39.6% (2,222 households), found in all villages with concentrations ranging from 6.8% in Sakhi Budruk to 89.7% in Sakhara Budruk.

Kolam communities constitute 20.4% of households (1,147) but show pronounced clustering patterns. Villages like Khairi (84.4% Kolam) and Mangurda (44.2% Kolam) represent Kolam-dominated settlements, while several villages have no Kolam presence.

Pardhan communities account for 8.8% of the households and cluster importantly in Tadumari (29.9%) and Both (17.1%).

Kunbi households (7.8% total) exhibit high concentration in certain villages, notably Sakhi Budruk (31.7%) and Karegaon Rampur (29.5%). The Kunbi people's long history of a connection with settled agriculture and market farming could cause them to be early adopters of new agricultural techniques, and they could be local sources of technology diffusion to surrounding tribal communities.

Scheduled Caste representation is confined to only three villages, with Mahar households being localized in Wai (15.6%) and Ganeshpur (15.0%). The limited distribution is due to historical settlement.

5 Healthcare Infra-structure and Accessibility

Table 4: Healthcare Facility Access Profile

Village Name	Nearest Sub-PHC	Sub-PHC Distance (km)	Nearest PHC	PHC Distance (km)	Healthcare Access Score*
Mangurda	Mangurda	0	Karanji	16	4.0
Wai	Wai	0	Karanji	12	4.0
Ganeshpur	Wai	2	Karanji	8.7	3.7
Dhoki	Wai	2.5	Karanji	4	3.9
Munzala	Munjala	0	Karanji	7	4.2
Wanjari	Wanjari	0	Pahapal	15	3.8
Zuli	Zuli	0	Pahapal	6	4.2
Both	Both	0	Pahapal	5	4.4
Niljai	Mangurda	12	Karanji	20	2.0
Ballarpur	Dhoki Road	17	Patan Bori	13	2.3
Khairgaon Deshmukh	Khairgaon Deshmukh	0	Khairgaon Deshmukh	0	4.4
Sakhi Budruk	Wai	13	Karanji	14	2.3
Karegaon Rampur	Khairgaon Deshmukh	0	Runza	5	4.4
Tembhi	Marathwakdi	7	Patan Bori	12	2.8
Wadvat	Chanakha	6	Arli	9	3.2
Karegaon Bandal	Arli	5	Arli	5	3.7
Khairi	Khairi	0	Arli	12	3.8
Wathoda	Meera	2	Runza	8	3.7
Tadumari	Tadumari	0	Karanji	42	2.5
Asoli	Mohada-2	3	Runza	7	3.7
Dabha (Mankar)	Patri	3	Runza	5	3.9
Chikaldara	Mohada-2	4	Runza	11	3.1
Sakhara Budruk	Dhoki	2	Patan Bori	15	3.3
Dariyapur	Khairi	15	Arli	7	2.7
Gopalpur	Akoli Budruk	0.5	Pahapal	18	3.0

*Healthcare Access Score: 1-5 scale based on proximity to Sub-PHC and PHC facilities.

THealthcare facility distribution shows that eight villages have Sub-PHCs inside village perimeters, which means instant access to the primary health services. The other villages reach Sub-PHCs at distances between 2 km and 17 km. In the case of Primary Health Centers with more specific care and treatment of acute ailments like pesticide poisoning, distances vary from 4 km (Dhoki) to 42 km (Tadumari).

Healthcare services in the study area are covered through six primary health centres (PHC's), each PHC supported by a network of Sub-PHC's that extend coverage into surrounding villages. All the PHC's are administered by Taluka Health Office. The study villages fall under the purview of all the 6 PHC's of Kelapur Taluka.

The Arli PHC, covers 14 villages across 7 Gram Panchayats, with Sub-PHC's functioning at Arli, Chanakha, Khairi and Rudha. The Patanbori PHC coverage is considerably larger, catering to 24 villages and 20 Gram Panchayats and is supported by Sub-PHC's situated in Dhoki, Kamalweli, Marathwakdi, Patan, Patanbori, Satpali, Sunna and Surdapur. The Pahapal PHC coverage is the most expansive, serving thirty-two villages and sixteen Gram Panchayats through Sub-PHC facilities at Akoli Budruk, Bhadumari, Borgaon, Both, Chalbardi, Kelapur, Pahapal 1, Pahapal 2, Sonbardi, Wangri and Zuli. The Khairgaon Deshmukh PHC covers 18 villages (13 Gram Panchayats) and in addition to its routine healthcare functions it also provides specialised services for surrounding villages under different PHCs, birth registrations and programme health management as a nodal centre. Its Sub-PHC's are located at Akoli Khurd, Kegaon, Khairgaon Deshmukh, Pimpri Road, Saykheda, Wagholi. The Karanji PHC extends services to 26 villages across 14 Gram Panchayats with Sub-PHC's in Adani, Dharna, Karanji, Mangi, Mangurda, Munzala, Sonurli, Tadumari and Wai. The Runza PHC provides healthcare to 19 villages (13 Gram Panchayats) supported by Sub-PHC's in Karegaon, Mira, Mohada -1, Mohada- 2, Pathri and Runza. Collectively, these 6 PHC's constitute the central framework of healthcare services in Kelapur Taluka.

In addition to the network of primary health centres, the study area is served by a sub-district hospital located in Kelapur Taluka headquarters, Pandharkawada town as the next level of health care facility. This hospital serves to provide diagnostic tests, in and out patient medical care for complex health conditions, specialist consultation and emergency services, and ensures referrals to specialised medical institutions as required.

Villages with excellent healthcare access (scores 4.0-5.0) include seven where both common and specialized care can be accessed at reasonable distances by villagers. On the other hand, six villages have low access scores (2.0-2.9), reflecting serious impediments to accessing healthcare, especially emergency care that can emanate from agrochemical use. However, overall healthcare access remains favourable as travel distances are minimal supported by improved road network.

Drinking Water Security and Quality Management

Table 5: Drinking Water Infrastructure and Quality Assessment

Village Name	Ground Water Source	Water Supply Mode	Quality Testing Status	Fluoride Level Monitoring	Availability Pattern	Water Security Risk
Mangurda	Yes	Tap Supply, RO Plant	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Wai	Yes	Tap Supply, RO Plant	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Ganeshpur	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Dhoki	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Munzala	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Wanjari	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Zuli	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Both	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Niljai	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Ballarpur	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Khairgaon Deshmukh	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Sakhi Budruk	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Karegaon Rampur	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Tembhi	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Wadvat	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Seasonal	Moderate
Karegaon Bandal	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Seasonal	Moderate
Khairi	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Seasonal	Moderate
Wathoda	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low

Tadumari	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Asoli	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Dabha (Mankar)	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Chikaldara	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low
Sakhara Budruk	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Seasonal	Moderate
Dariyapur	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Seasonal	Moderate
Gopalpur	Yes	Tap Supply	Monthly testing by MJP	Within limits (<1.5 mg/L)	Perennial	Low

*MJP: Maharashtra Jeevan Pradhikaran.

Every village has operational groundwater sources with tap supply systems. Maharashtra Jeevan Pradhikaran runs periodic water quality analysis on a monthly basis for fluoride content, Total Dissolved Solids (TDS), bacterial fouling, and pH levels. At present, all borewells are running within safe limits of fluoride (<1.5 mg/L), although surveillance is ongoing because of local apprehensions regarding groundwater fouling. It incorporates borewell sealing protocols if the fluoride content is above 1.5 mg/L or other parameters cross safety limits. This becomes especially significant in the context of agricultural intensification, as higher chemical applications could potentially compromise groundwater quality in the long run.

Five villages (Wadvat, Karegaon Bandal, Khairi, Sakhara Budruk, Dariyapur) have seasonal availability of drinking water, usually during summer periods when groundwater is relatively low. The seasonal limitation overlaps with the season of intensive agricultural preparation work, which may build on top of stress on households at crucial times in agriculture.

Mangurda and Wai, and several other villages have RO plants, such installations add water security.

Agricultural Irrigation Infrastructure

Table 6: Irrigation Infrastructure and Farmer Access Patterns

Village Name	Primary Irrigation Source	Farmer Access Rate*	Monsoon Dependency**	Secondary Source	Summer Water Stress Level
Mangurda	Ground Water (Borewells)	35%	High (65%)	Nil	Moderate
Wai	Ground Water (Borewells)	42%	Moderate (58%)	Surface Water	Moderate
Ganeshpur	Ground Water (Borewells)	28%	High (72%)	Nil	High
Dhoki	Ground Water (Borewells)	31%	High (69%)	Nil	High
Munzala	Ground Water (Borewells)	38%	Moderate (62%)	Nil	Moderate
Wanjari	Ground Water (Borewells)	25%	High (75%)	Nil	High
Zuli	Ground Water (Borewells)	33%	High (67%)	Nil	High
Both	Ground Water (Borewells)	29%	High (71%)	Surface Water	High
Niljai	Ground Water (Borewells)	45%	Moderate (55%)	Nil	Moderate
Ballarpur	Ground Water (Borewells)	22%	High (78%)	Nil	High
Khairgaon Deshmukh	Ground Water (Borewells)	48%	Moderate (52%)	Nil	Low
Sakhi Budruk	Ground Water (Borewells)	36%	High (64%)	Nil	Moderate
Karegaon Rampur	Ground Water (Borewells)	52%	Low (48%)	Canal Access	Low
Tembhi	Ground Water (Borewells)	26%	High (74%)	Nil	High
Wadvat	Ground Water (Borewells)	18%	Very High (82%)	Nil	Very High
Karegaon Bandal	Ground Water (Borewells)	34%	Moderate (66%)	Canal Access	Moderate
Khairi	Ground Water (Borewells)	21%	High (79%)	Nil	High
Wathoda	Ground Water (Borewells)	41%	Low (59%)	River Pumping	Low
Tadumari	Ground Water (Borewells)	39%	Moderate (61%)	Nil	Moderate

Asoli	Ground Water (Borewells)	44%	Low (56%)	River Pumping	Low
Dabha (Mankar)	Ground Water (Borewells)	37%	High (63%)	Nil	Moderate
Chikaldara	Ground Water (Borewells)	32%	High (68%)	Nil	High
Sakhara Budruk	Ground Water (Borewells)	19%	Very High (81%)	Nil	Very High
Dariyapur	Ground Water (Borewells)	15%	Very High (85%)	Nil	Very High
Gopalpur	Ground Water (Borewells)	43%	Moderate (57%)	Surface Water	Moderate

*Farmer Access Rate: Percentage of farmers with individual borewell irrigation facilities.
**Monsoon Dependency: Percentage of farmers relying primarily on rainfall for agriculture.

Farmer access to irrigation facilities differs widely between villages, ranging from 15% in Dariyapur to 52% in Karegaon Rampur. This diversity actually determines farming practices, with farmers lacking irrigation engage in rain-fed farming with alternative crop choice, input use, and risk management practices than farmers with guaranteed irrigation. However, crop choices largely converge across Kelapur Taluka as the region is dominated by cotton monoculture.

Extreme monsoon dependency rates (48-85% of farmers in villages) express the dominant dependence on seasonal rains for farming. This dependence contributes to much year-to-year variability in farm success and could affect input use decisions for farming, crop intensification, and risk-taking activities that modulate health exposures.

Summer water stress levels are highly correlated with irrigation access rates. Very high summer stress villages (Wadvat, Sakhara Budruk, Dariyapur) have the lowest irrigation access and highest monsoon dependence, leading to severe agricultural constraints during March-May periods when groundwater levels fall significantly.

Kelapur's tropical semi-arid climatic conditions (20ºN latitude) generate regular seasonal patterns of water stress. Rainfall of 800-1200 mm falls between the months of June-September, after which there is a long dry spell with temperatures ranging from 35-45ºC and much depleted groundwater levels.

Surface Water Irrigation Systems

Table 7: Surface Water and Canal Irrigation Access

Village Name	Surface Water Source	Distance from Fields	Farmers Utilizing	Pumping Infrastructure	Seasonal Availability	Water Management Issues
Karegaon Rampur	Painganga Canal Branch	0.5-2 km	47 farmers (14%)	Electric pump systems	June-October	Water sharing disputes
Karegaon Bandal	Painganga Canal Branch	1-3 km	32 farmers (15%)	Electric pump systems	June-September	Unauthorized connections
Wathoda	Wardha River tributary	0.3-1.5 km	38 farmers (14%)	Diesel pump systems	July-November	Riverbed cultivation conflicts

Three villages have developed access to surface water sources for irrigation by direct pumping arrangements. The systems benefit about 14-15% of farmers in each of the impacted villages, offering substitute water sources during times when surface water is present.

Canal access in Karegaon Rampur and Karegaon Bandal entails farmers whose fields are located within 1-3 km of Painganga Canal branches. Farmers have installed pumping equipment to draw water directly from the canal, although such arrangements occasionally function within a regulatory grey area and may generate disputes over water rights and usage timetables.

In Wathoda, farmers having fields adjacent to Wardha River tributary draw flowing water during monsoon and post-monsoon seasons. Strategic location of fields and pumping capital investment are necessary for this access, providing benefits to farmers who have appropriate landholdings close to water resources.

Water management problems in such villages involve conflicts over timing access, illegal connections, and disagreement stemming from riverbed cultivation activities. Such management problems could impact agricultural and interactions among people in ways that influence farming activities as well as health outcomes.

Agricultural Extension Services

The agricultural extension system operates through Pandharkawada serving all villages in Kelapur Taluka. Agriculture Extension office distances vary between 5 km (Mangurda) and 40 km (Dariyapur), leading to considerable disparity in farmers physical access to services agriculture department for agricultural information. This disparity is alleviated to some extent through services that reach villages under specific programmes and occasional field visits.

Table 8: Agricultural Extension Office Accessibility

Village Name	Nearest Agricultural Office	Distance (km)	Extension Access Score*
Mangurda	Pandharkawada	5	4.2
Wai	Pandharkawada	14	3.5
Ganeshpur	Pandharkawada	8	3.9
Dhoki	Pandharkawada	12	3.5
Munzala	Pandharkawada	18	3
Wanjari	Pandharkawada	15	3.5
Zuli	Pandharkawada	22	2.7
Both	Pandharkawada	20	3
Niljai	Pandharkawada	10	3.9
Ballarpur	Pandharkawada	16	3
Khairgaon Deshmukh	Pandharkawada	13	3.5
Sakhi Budruk	Pandharkawada	14	3.5
Karegaon Rampur	Pandharkawada	25	2.7
Tembhi	Pandharkawada	18	3
Wadvat	Pandharkawada	35	2.2
Karegaon Bandal	Pandharkawada	30	2.4
Khairi	Pandharkawada	28	2.4
Wathoda	Pandharkawada	22	2.7
Tadumari	Pandharkawada	12	3.5
Asoli	Pandharkawada	25	2.7
Dabha (Mankar)	Pandharkawada	20	3
Chikaldara	Pandharkawada	35	2.2
Sakhara Budruk	Pandharkawada	15	3.5
Dariyapur	Pandharkawada	40	2
Gopalpur	Pandharkawada	18	3

*Extension Access Score: 1-5 scale based on distance and service frequency

Climatic Context and Seasonal Stress Patterns:

Kelapur Taluka, located at approximately 20ºN latitude and is in the tropical semi-arid climatic regime with clear wet and dry seasons (Gadgil & Gadgil, 2006). There is an annual rainfall of 800-1200 mm in the area, with about 85% receiving rain during the southwest monsoon months from June to September (India Meteorological Department, 2020).

Summer temperatures are 35-45ºC in March-May, causing severe water stress conditions as groundwater levels reduce by 3-8 meters from post-monsoon levels. This climatic pattern strongly affects agricultural practices, water availability, and health stress patterns in the study villages.

Table 9: Seasonal Water Stress and Agricultural Impact Analysis

Season	Groundwater Status	Agricultural Activities	Villages Severely Affected	Health Implications
Pre-Monsoon (March-May)	Severe depletion (3-8m drop)	Land preparation, seed treatment	15 villages	Heat stress, chemical exposure
Monsoon (June-September)	Variable recharge	Sowing, pest management	7 villages (poor recharge)	Water-borne diseases, pesticide exposure
Post-Monsoon (October-February)	Gradual decline	Harvesting, rabi cultivation	All villages	Respiratory issues, harvest chemicals

Seasonal water stress pattern produces temporal aggregation of health hazards, where summer chemical preparation processes overlap with maximum water shortage and heat stress situations. This temporal correlation between environmental stress and use of agricultural chemicals is a key consideration for health impact assessment.

APPENDIX II

Commonly used Agro-chemicals & Hazardous effects on Human Health

Most commonly used Chemical fertilizers

- ✓ Urea
- ✓ Di-ammonium Phosphate popularly known as DAP
- ✓ Potash
- ✓ 10-26-26
- ✓ 18-18-10
- ✓ 20-20-0-13 (Ammonium Phosphate)
- ✓ Super Phosphate
- ✓ 15-15-15
- ✓ 12-32-16
- ✓ 14-35-14

Most commonly used Pesticides

- ➢ Profex Super (Profenofos)
- ➢ Quinalphos (25% EC)
- ➢ Confidor (Imidacloprid 17.1%)
- ➢ Asataf (Acephate 75% SP)
- ➢ Monocil (Monocrotophos 36% SL)
- ➢ Ulala (Flonicamid 50 WG)
- ➢ Emamectin benzoate
- ➢ Police

Most commonly used Herbicides

- Roundup (Glyphosate 41% SL)
- Glycel (Glyphosate 41% SL)
- Seedpower (Glufosinate Ammonium)
- Lancer Gold
- Hitweed Maxx
- Hitweed
- Weed Super
- Dozo Maxx and Impool
- Sweep Power

Hazardous effects

- Most dangerous insecticide is *Profex Super* (content Profenofos, used solely on cotton). It can cause death, vision loss and hospitalization.
- *Quinalphos (25% EC)*, often used as a substitute to Profex Super is equally harmful.
- *Monocil* is in liquid form, the other insecticides are in the form of powder.
- *Emamectin benzoate* is mixed with Mono/Asataf/Lancer Gold and then sprayed on the crops.
- Insecticides have to be sprayed 8-9 times in the field depending on diseases and pests infesting frequencies.

APPENDIX III

Disease Classification

Classification of Morbidity by Disease: Main Disease Categories and Associated Conditions

Sl. No.	Classification Disease/Illness
1	Agrochemical Induced Conditions (Fertilizer-Induced Gastroenteropathy, Pesticide-Induced Neuropathy, Pesticide-Induced Ocular Toxicity, Cardiorespiratory-Pesticide Spray-Induced)
2	Cancers (Breast surgery – suspected breast cancer, Stomach tumor)
3	Cardiovascular & Circulatory Disorders (Cardiac Valve Surgery, Cardio-Alimentary Distress, Chest Pain, Coughing and chest pain, Heart Attack, Hypertensive disease, Hypertensive-Diabetic, Ischemic heart disease, Oculocardiac reflex, Paralysis, Thoracic problem)
4	Cyst/Benign Tumor (Armpit cyst and history of eye surgery, Eye tumour, Hand tumor, Uterus cyst)
5	Dermatological Conditions (Skin erosion on feet, Skin infection)
6	Disability / Functional Impairment (Hearing loss, Specially abled)
7	Endocrine & Metabolic Disorders (Diabetes, Hypothyroidism, Thyroid)
8	Eye & Vision Disorders (Eye swelling, Eye pruritus – itchy eyes, Right eye problem, Eye infection)
9	Gastrointestinal & Hepatic Disorders (Anorexia, Appendicitis, Liver Cirrhosis, Piles, Rectal bleeding, Stomach problem)
10	Infectious & Parasitic Diseases (Dengue, Diarrheal diseases, Leprosy, Respiratory infection, Tuberculosis, Typhoid)
11	Musculoskeletal Disorders (Arthritis, Gap deformity of the leg, Knee problem, Left palm surgery)
12	Others (Uterus Swelling, Aging related Problem, very weak)
13	Renal & Urological Disorders (Hydrocil, Kidney stone, small kidney, Kidney swelling)
14	Respiratory Disorders (Respiratory diseases, Throat problem, Acute bronchospasm)
15	Sickle Cell Anaemia (Sickle cell anaemia)
16	Animal related Injury (Wild Boar Injury)
17	Neurological Disorders (Seizures, Speech impairment, Anxiety, Headache, Lumbo-Vestibular Syndrome, Psychiatric disorder)

Classification of Morbidity by Disease: Main Disease Categories and Associated Conditions

Sl.No.	Classification Disease/Illness
1	Agro-Chemical Induced Conditions (Pesticide-induced)
2	Musculoskeletal Disorders (Body pain/back pain issues, Leg problem, Leg swelling and body swelling)
3	Neurological and Mental Health (Brain attack, Brain haemorrhage, Mental illness, Mental problem, Mentally impaired, Seizures, Mirgi)
4	Cancers (Blood cancer, Brain cancer, Breast cancer, Cancer, Mouth cancer, Oral cancer, Tumor in stomach, Stomach cancer, Thoracic cancer due to smoking)
5	Cardiovascular & Circulatory Diseases (BP + Fever, BP & Heart attack, Chest problem, Heart attack, Heart disease, Heart problem, Paralysis)
6	Chronic Alcohol Consumption (Excessive Alcohol)
7	Elderly Natural Death (Aging, Old age and illness)
8	Endocrine and Metabolic Disorders (Diabetes)
9	Gastrointestinal and Liver Disorders (Dehydration and stomach issue, Excessive loose motion and vomiting, Liver damage due to alcohol, Liver disease, Liver failure, Stomach problem)
10	Maternal & Perinatal and Gynaecological (Maternal mortality, Maternal mortality with foetal death, Illness with white discharge, Sudden death–uterus removal, Uterus issue)
11	Renal and Urogenital (Kidney failure, Kidney stone, Kidney swelling and valve damage)
12	Respiratory (Dama, Asthma attack [sudden], Oesophagus issue)
13	Sickle Cell Anaemia (Sickle cell anaemia)
14	Unclassified Or Unspecified (Cannot say, Deceased, Illness, Reason unknown)
15	Hepatic (Jaundice)
16	Infectious & Parasitic Diseases (Tuberculosis, Brain fever, COVID, Leprosy, Pneumonia with incomplete TB treatment, Sepsis)
17	Unnatural Death (Accident, Bike accident, Consumed poison while intoxicated, Dog bite, Snake bite, Suicide)
18	Vector-borne Diseases (Dengue, Malaria, Chikungunya)

APPENDIX IV

PHOTOGRAPHS

Farmer carrying cotton in a bullock cart to sell in the nearby factory, Mangurda

Filling of cotton in the truck in progress, for taking to sell, Wathoda

Storing cotton in house, after this year's harvest, Karegaon Bundle

Stored cotton, just after plucking, Dhoki

Cotton field in full bloom, while cotton plucking is taking place, Mangurda

Cotton plants, after cotton is plucked,

Barren cotton field, Daryapur

Team photo along with doctors, in front of a local PHC, Mangurda

Watermelon field, Khairgaon Desmukh

Organic Insecticide, and Fertilizer, Tad Umari

Herding out for evening graze, Zuli

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