Research Article:

UNDERSTANDING CLIMATE CHANGE THROUGH FARMERS, METEOROLOGICAL EVIDENCE, AND RAPESEED YIELD UNDER STAGGERED PLANTING DATES IN TIKAPUR, KAILALI

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ABSTRACT

Climate change poses a serious challenge to agriculture-dependent regions such as the western Terai of Nepal. This study assessed farmers' perceptions of climate change, analyzed long-term climatic trends, and evaluated the performance of rapeseed (*Brassica campestris* L. var. *toria*) under different sowing dates in Tikapur Municipality, Kailali. Household surveys documented farmers' experiences and adaptation practices, while historical meteorological data (1990–2020) were analyzed using the non-parametric Mann–Kendall test. Farmer-managed on-farm experiments were conducted to compare rapeseed yield across three sowing dates. More than 81% of farmers perceived increasing summer temperatures, shorter and warmer winters, and more erratic and declining rainfall. Climatic analysis confirmed decreasing trends in annual, monsoon, and winter rainfall by 3.52, 2.92, and 0.65 mm yr^{-1}, respectively, along with an increasing trend in summer maximum temperature. Summer minimum temperature declined by 0.014–0.029 °C yr^{-1}, while winter minimum and maximum temperatures showed mixed trends. Field results showed significant yield differences among sowing dates, with the highest yield obtained from crops sown in the first fortnight of Ashwin. Overall, adjusting sowing dates emerged as an effective and practical climate adaptation strategy for rapeseed production in the western Terai.

सारांश

जलवायु परिवर्तन एक विश्वव्यापी चुनौति हो । यसको विषेश प्रभाव नेपाल जस्ता कृषिमा आश्रित अर्थतन्त्र भएका विकासशील राष्ट्रहरूमा अधिक पर्ने गर्दछ । यसै 'जलवायु' परिवर्तन सम्बन्धी कृषकहरूको धारणा बुझ्न र बदलिँदो जलवायुमा विभिन्न मितिमा रोपिएका तोरीको उत्पादनमा हुन सक्ने प्रभाव मूल्याङ्कन गर्दै उद्देश्यले कैलाली जिल्लाको टिकापुर नगरपालिकामा सर्वेक्षण तथा बाली प्रयोगको संयुक्त अध्ययन गरिएको थियो । सन् १९९०-२०२० सम्मको मौसमसम्बन्धी ऐतिहासिक तथ्याङ्कलाई Mann Kendall परीक्षण प्रयोग गरी विश्लेषण गरिएको थियो । किसानको व्यवस्थापनमा खेतस्तरीय प्रयोग सञ्चालन गरी तीन फरक मितिहरूमा रोपिएका तोरीको उत्पादन तुलना गरियो । अध्ययनको नतिजा अनुसार ८१ प्रतिशतभन्दा बढी किसानहरूले गर्मीको तापक्रम बढ्दै गएको, जाडो छोटो तथा न्यानो हुँदै गएको र वर्षा अनियमित तथा घट्दो भएको अनुभव गरेका थिए । त्यसै गरी अध्ययनका क्रममा गरिएको जलवायु विश्लेषणले वार्षिक, मनसुन र जाडो वर्षामा क्रमशः ३.५२, २.९२ र ०.६५ मि.मि. प्रति वर्षको घट्दो प्रवृत्ति र गर्मीको अधिकतम तापक्रम बढ्दो क्रममा रहेको पुष्टि गर्‍यो । गर्मीको न्यूनतम तापक्रम ०.०१४-०.०२९ °C प्रति वर्षले घटेको देखियो भने जाडोको न्यूनतम र अधिकतम तापक्रममा मिश्रित प्रवृत्ति देखियो । किसानको खेतमा विभिन्न मितिमा रोपिएका तोरीको उत्पादन हेर्दा उल्लेख्य भिन्नता देखियो, जसमा आश्विनको पहिलो पन्ध्रदिनमा रोपिएको तोरीबाट सबैभन्दा बढी उत्पादन भएको देखियो । समग्रमा, तोरी लगाउने मिति समायोजन गर्नु पश्चिम तराईमा तोरी उत्पादनका लागि प्रभावकारी तथा व्यवहारिक जलवायु अनुकूलन रणनीतिका रूपमा देखियो ।

Keywords: Adaptation, perception, trend

INTRODUCTION

Climate change and its impacts exhibit considerable variation globally, manifested through rising temperatures, droughts, heatwaves, melting snow, sea-level rise, and flooding (Maclean and Wilson, 2011). Although these impacts are global, the poorest countries and their populations are expected to suffer disproportionately due to low adaptive capacity and heavy dependence on climate-sensitive agriculture (ICIMOD, 2010). Climatic variability alone accounts for nearly 60% of yield fluctuations, underscoring its critical influence on food production and farmers' livelihoods (Osborne and Wheeler, 2013; Ray et al., 2015; Matiu et al., 2017). Changes in temperature and rainfall affect the initiation and duration of growing periods (Fiwa et al., 2014; Zhao et al., 2015; Lemma et al., 2016), as well as the intensity and timing of heat and water stress in agricultural systems (Lobell et al., 2015; Saadi et al., 2015; Schauberger et al., 2017).

In South Asia, even a modest temperature increase of 1.5–2°C can substantially alter water availability due to increased monsoon variability and glacial melt, posing serious risks to agricultural productivity (Vinke et al., 2017). These climatic disruptions are expected to intensify fluctuations in food supply and market prices, thereby aggravating food insecurity and poverty across the region (Bandara and Cai, 2014; Schmidhuber and Tubiello, 2007; Shankar et al., 2015; Wang et al., 2017; Aryal et al., 2019). Nepal is particularly vulnerable to such changes, being ranked among the most climate-sensitive countries due to its exposure to extreme weather events and increasing seasonal variability (Ministry of Environment, 2010; Paudel, 2010, 2012; Field et al., 2012). In recent decades, the country has experienced frequent floods and droughts driven by altered rainfall intensity and distribution (Krishnamurthy et al., 2013; Adhikari, 2018).

Within Nepal's agricultural system, rapeseed plays a vital role due to its adaptability and integration into the rice–oilseed cropping system of the Terai and inner Terai regions (Ghimire et al., 2000). It is the third most important crop after cereals and legumes in terms of area and production, accounting for about 80% of the country's total oilseed area (Ojha et al., 2018). Kailali district is the leading producer of rapeseed, with an average productivity of 1.24 Mt ha^{-1} (MoALD, 2019). However, rapeseed is highly sensitive to climatic conditions, particularly temperature and moisture regimes, as reflected in its variable response to sowing dates (Kumar et al., 2007). Increases in temperature and reductions in precipitation significantly influence yield and seed oil content (Walton et al., 1999; Si and Walton, 2004; Vernon and van Gool, 2006; Namazkar et al., 2016), and recent evidence suggests that Nepal's rapeseed production is already being affected by climate change (Acharya et al., 2021). These sensitivities highlight the importance of understanding crop–climate interactions under local conditions.

While global and regional climate models provide valuable projections, they often fail to capture localized climatic dynamics and their site-specific impacts on farming systems (IPCC, 2007). Consequently, incorporating farmers' perceptions becomes essential, as local farmers are keen observers of environmental change and base their management decisions on lived experience (Jin et al., 2015; Niles and Mueller, 2016). Farmers' perceptions not only influence on-farm adaptation choices but also provide critical insights for designing locally relevant adaptation strategies (Abid et al., 2019). Across Nepal, farmers have responded to climate variability by adjusting planting dates, modifying crop and varietal choices, improving soil and water management, and altering farm operations (Giri et al., 2015; Dahal et al., 2018; Khanal et al., 2017; Maharjan et al., 2017; Acharya et al., 2021).

Numerous studies across diverse agro-climatic conditions have demonstrated that sowing date strongly influences rapeseed growth, yield, and quality (Christensen et al., 1985; Taylor and Smith, 1992; Hocking et al., 2001). Variations in sowing time expose crops to different thermal and moisture environments within the same location, thereby affecting phenological development and productivity (Pandey et al., 1981). Despite this knowledge, there remains a clear gap in studies that simultaneously link measured climatic trends, farmers' perceptions, and field-level crop responses under real farming conditions in Nepal's western Terai.

Therefore, integrating long-term climatic trend analysis with farmers' perceptions and on-farm experimentation is scientifically important to validate local knowledge, explain observed yield responses, and identify practical, low-cost adaptation options such as optimized planting dates. In this context, the present study was conducted in Tikapur Municipality to evaluate the performance of rapeseed under different sowing dates in a changing climatic scenario while simultaneously examining farmers' perceptions, experiences, and adaptation measures related to climate change.

RESEARCH METHODS

The purposive sampling method includes thirty household surveys from nine wards of Tikapur Municipality (personal respondents), three key informant interviews (KII) and one focused group discussion (FGD) were conducted in August 2020 in conjunction with multi-year meteorological data obtained from the Department of Hydrology and Meteorology, Mid and Far Western Regional Climate Office, Surkhet. The survey was further supplemented with field experiments from September 2020 to February 2021. Both the studies (field survey and on-farm experimental trail) were conducted in Tikapur Municipality (28°31'30"N, 81°07'15"E & 256 masl.). The meteorological data of 30 years (1990-2020) were analyzed using Mann-Kendell test in XL-STAT (Gilbert, 1987).

$$S=\sum_{k-1}^{n-1} \square \sum_{j=k+1}^{n} \square \text{ sign}(x\_j-x\_k)$$

Where, $x_{1,}\ x_{2\ldots\ldots}x_n$ represents n data points and x_j represents data points at j time.

The on-farm experiment was carried out in twenty-seven farmer's fields as purposive sampling with quota method. Three farmers with three different sowing dates in each ward of Tikapur Municipality were selected using local rapeseed germplasm. The experiment was conducted in Randomized Complete Block Design (RCBD) having three treatments; sowing at 1st Fortnight of Ashwin (16 Sept 2020), sowing at 2nd Fortnight of Ashwin (1 Oct 2020) and sowing at 1st Fortnight of Kartik (15 Oct 2020), and nine wards as replications. From a farmer's field, a plot size of 100 m^2 was studied**.** Farmer's self-management practice was followed until the crop maturity stage. In the study area farmers commonly use broadcasting methods for sowing in rapeseed rather than row planting; therefore, sowing creates an irregular plant spacing and variable plant density. Plant population was therefore measured as plants per square meter (plants m^{-2}) using 1 m^2 crop-cut quadrats at maturity. The populations observed in the research trial range from 99 to 136 plants m^{-2} across planting dates. There is also variability in irrigation. Mostly are rainfed conditions. However, few households reported with 1-2 flood irrigation before flowering and at the pod filling stage. Farmers in the study area applied fertilizers according to their usual practice, mainly Urea, DAP, and farmyard manure (FYM). Typical fertilizer use for rapeseed/mustard in the Terai lies around 60:40:20 kg ha^{-1} of N:P: K while apply FYM at approximately 1.5–2.5 t ha^{-1}, depending on availability. All the households follow rice–mustard system.

The on-farm experiment employed a purposive sampling design combined with quota sampling to ensure balanced spatial representation and treatment allocation. Tikapur Municipality consists of nine wards; each treated as a quota. From each ward, three farmers were purposively selected based on their experience in rapeseed cultivation, willingness to participate, and land suitability. Each farmer represented one of the three sowing-date treatments (first fortnight of Ashwin, second fortnight of Ashwin, and first fortnight of Kartik), resulting in a total of twenty-seven experimental fields (3 farmers × 9 wards). This design ensured equal representation of sowing-date treatments across wards and minimized location-specific bias.

For the household survey, thirty households were selected using purposive sampling across the same nine wards. Three households were selected per ward (n = 27), and an additional three households were included to increase sample size and maintain adequate degrees of freedom for statistical analysis, resulting in a total of thirty respondents. This approach allowed sufficient variability in household characteristics, management practices, and climate-related experiences while maintaining analytical robustness.

The different yield attributing characters like plant population, number of branches/plants, number of silique/plants, number of seeds/siliqua, seed and stalk yield and test weight were recorded after post-harvest. The on-farm field experiment data were analyzed using R-Stat Version 4.1.2 for Analysis of Variance to test the significance of difference for each parameter. Calculation of the significant critical differences at 5% level of significance was made by comparing means using Duncan's Multiple Range Test (DMRT). Analysis of variance and LSD mean separations was done from the reference of Gomez and Gomez (1984).

Limitations of the study

A key limitation of this study is the farmer-managed conditions. In the study area, rapeseed is predominantly sown through broadcasting, which results in irregular plant spacing and heterogeneous plant density. Additionally, although the system is primarily rainfed, a few households reported applying one to two flood irrigations before flowering or during the pod-filling stage, introducing further inconsistency in soil moisture availability. Farmers also differed in nutrient application, relying on their customary use of Urea, DAP, and FYM depending on resource availability. Together, these uncontrolled differences in sowing method, plant density, irrigation, and nutrient management represent sources of environmental variation that may have affected crop performance and therefore constitute a limitation of this study.

With respect to climatic trend analysis, the Mann–Kendall test was applied to identify the direction and significance of trends in temperature and rainfall. However, complete reporting of Kendall's tau and Z-statistics was not possible for all variables due to constraints in retrieving the full set of statistical outputs from the original meteorological dataset. As a result, trend interpretation focused on Sen's slope estimates and associated p-values, which still provide a robust indication of trend magnitude and significance.

RESULTS AND DISCUSSION

Local people's perception on climate change and its adaptation measures

When asked to the local rapeseed grower in a household survey, more than 80% of people have noticed the long-term shift in temperature and precipitation. Based on their past experiences, 67% respondents said that warming has increased and days are getting hotter. Further talking about seasonal variation, more than 50% farmers agreed that summer temperature is increasing and winters are getting shorter and warmer, while 32% felt the cooler winters. In case of precipitation, the majority of people mentioned the rainfall pattern has become more unpredictable and erratic in the last decade affecting their traditional annual crop calendar. More than 30% of respondents said that total annual rainfall has increased but around 60% agreed on decreasing winter rainfall and radio was the major source of information for farmers to get acquainted with climate change.

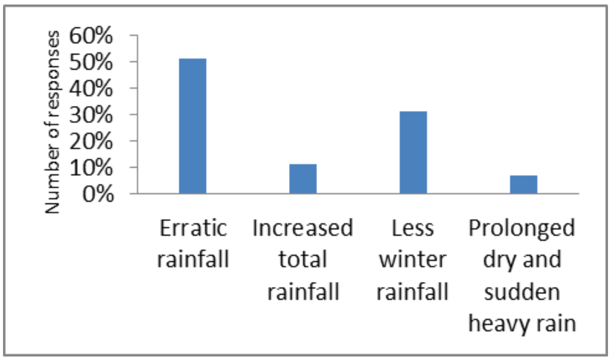


Fig. 1. Response on seasonal temp. variability

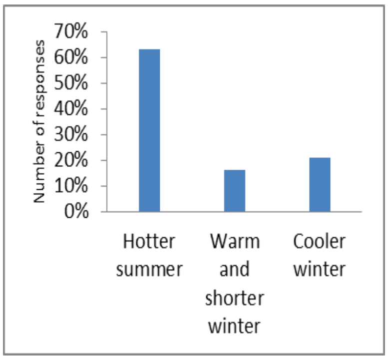


Fig. 2. Response on seasonal precipitation variability

To cope with the changing climate, local pupils in the area adopted various climate change adaptation measures. For example, more than half of the respondents (51%) reported changing the date of sowing due to an uncertain onset and cessation of rainfall. Around 14% respondents used balanced fertilizers, 11% switched to local varieties, 7% added irrigation, 8% used a combination of practices and 9% did nothing.

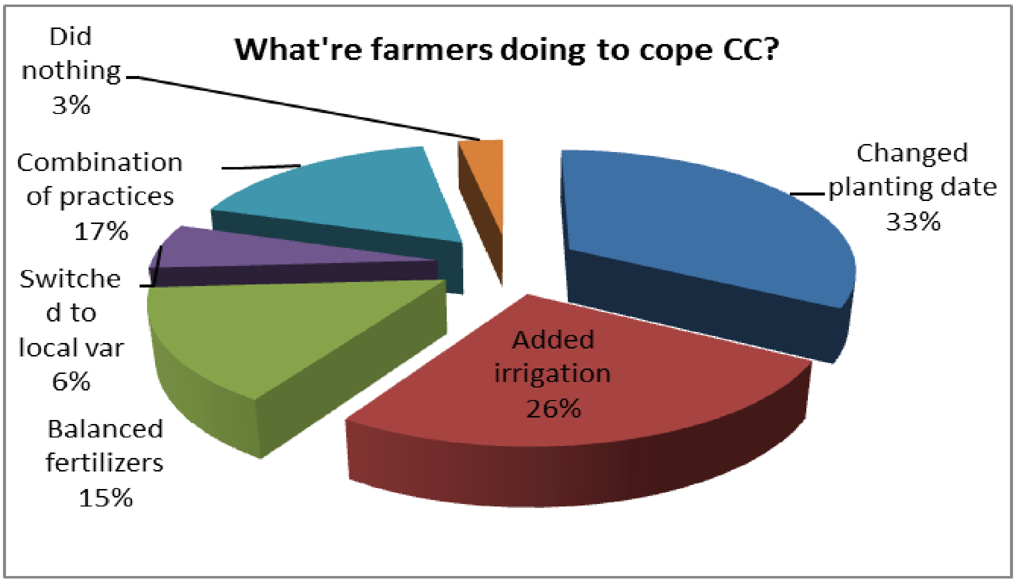


Fig. 3. Farmers practices towards adaptation on climate change (CC)

Agro-meteorological evidence of climate change

Since the seasonal temperature and variation in temperature can significantly affect the overall trend, it is of interest to find the trends for each season which hold true for seasonal precipitation too. Specifically, monthly trend was analyzed separately for summer and winter temperature and in case of precipitation, total annual, monsoon and winter rainfall trend were analyzed. The results of Mann Kendall test for variation in average maximum and minimum seasonal temperature and precipitation in the 31 years period of 1990-2020 are presented in Fig. 4, Fig. 5 & Fig. 6.

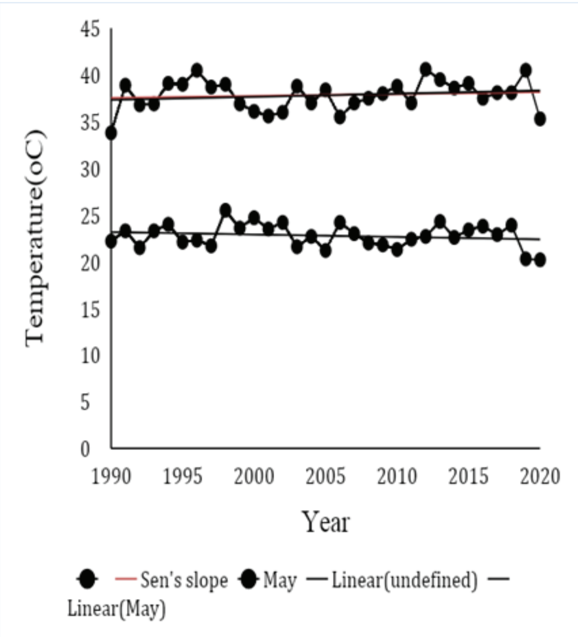
Average maximum and minimum temperature during summer (May-Aug)

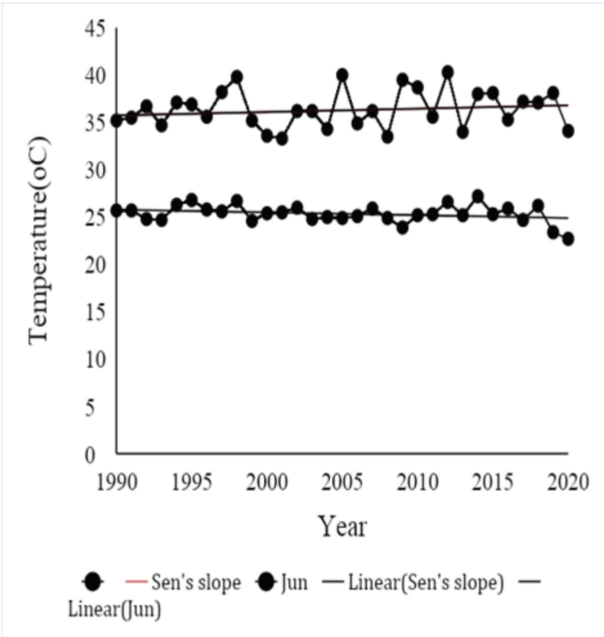
The trend of average maximum temperature during summer (May-Aug) in the 31 years period shows an increasing trend. In first two months of summer, i.e. May and June, the trend of average maximum temperature increased by 0.021 ^{0}C/year and 0.036 ^{0}C/year, respectively and both the trends are statistically non-significant at the 95% level. However, in July and August, the trend increased by 0.042 ^{0}C/year and 0.071 ^{0}C/year, respectively, where the trend of July is statistically significant with p-value 0.005 and of August is with p-value <0.0001.

The stronger warming of Tmax during July and August may be associated with increased atmospheric moisture, enhanced greenhouse forcing, and changes in cloud dynamics during the peak monsoon period. Elevated humidity and reduced evaporative cooling can amplify daytime heat accumulation, particularly during periods of intermittent cloud cover and high solar radiation (IPCC, 2013; Trenberth et al., 2014). Similar seasonal amplification of summer Tmax has been reported across South Asia, especially in the Terai region, where monsoon variability interacts with land–atmosphere feedback (Shrestha et al., 2017).

The trend of average minimum temperature during summer (May-Aug) in the 31 years period shows a decreasing trend. In four months (May-Aug) the weather trend decreased by 0.029 ^{0}C/year, 0.023 ^{0}C/year, 0.014 ^{0}C/year, and 0.018^{0}C/year, respectively and all the trends are statistically non- significant at the 95% level.

The contrasting behavior between maximum and minimum temperatures may be explained by changes in nighttime radiative cooling, cloud cover variability, and land-use dynamics. In agricultural landscapes such as the western Terai, reduced cloud cover during nighttime, declining soil moisture, and increased surface roughness following harvest periods can enhance long-wave radiation loss, leading to cooler night temperatures despite rising daytime heat (Dai et al., 1999; You et al., 2017). Additionally, irrigation withdrawal and rainfed conditions during early summer may reduce near-surface humidity at night, suppressing Tmin more than Tmax (Lobell et al., 2006). Such asymmetric warming where Tmax increases faster or Tmin stagnates or declines has also been observed in parts of South Asia and is often linked to monsoon variability and localized land–atmosphere interactions (Kattel et al., 2013; Shrestha et al., 2019).





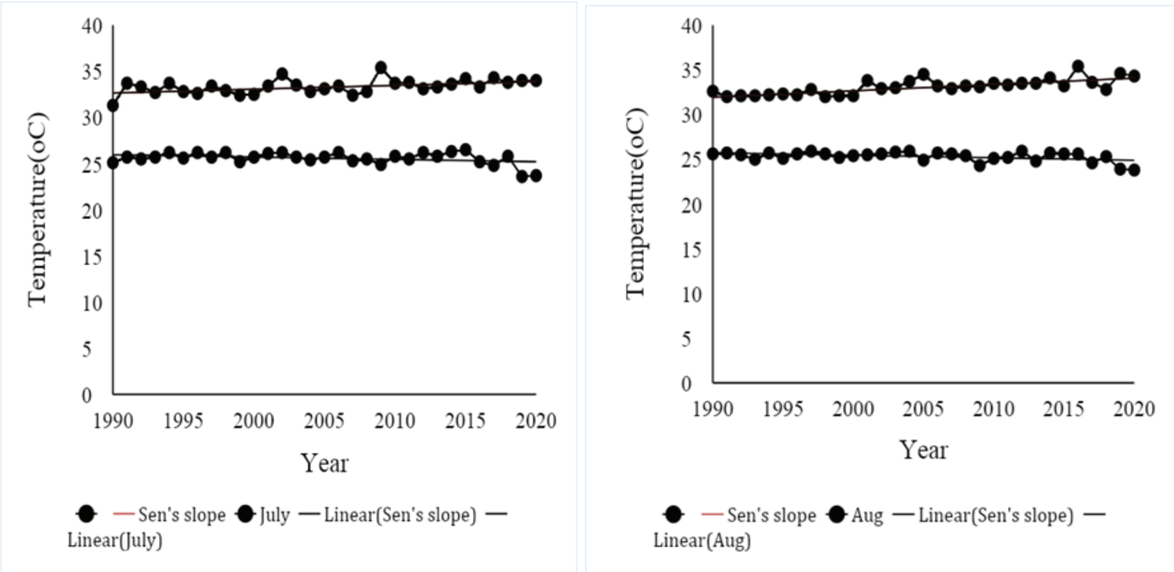


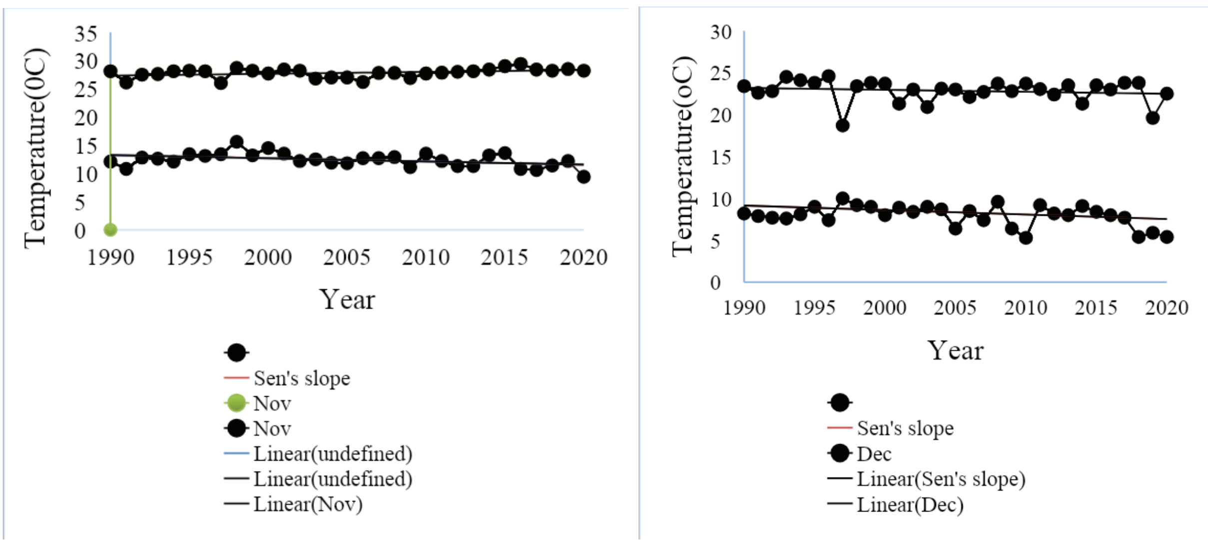
Fig. 4. Trend of average minimum and maximum temperature during 1990-2020 period in Tikapur for summer (May- August), respectively

Source: DHM, Mid and Far Western Regional Climate Office, Surkhet

Average minimum and maximum winter temperature (Nov-Feb)

The trend of average minimum temperature during winter (Nov-Feb) in the last 31 years period shows an increasing trend. In the first two months of winter (November and December), the trend of average minimum temperature decreased by 0.058^{0}C/year and 0.054^{0}C/year respectively. However, in January no such trend is observed but in February, the trend is increased by 0.011^{0}C/year where all the trends are statistically non- significant at the 95% level.

Similarly, the trend of average maximum temperature during winter (Nov-Feb) in the 31 years period shows a mixed trend (increasing and decreasing). In November the trend of average maximum temperature increased by 0.033^{0}C/year, whereas in the month of December and January it decreased by 0.02^{0}C/year and 0.007^{0}C/year, respectively. Further in February, the trend increased by 0.045^{0}C/year, where all the trends are statistically non- significant at the 95% level.



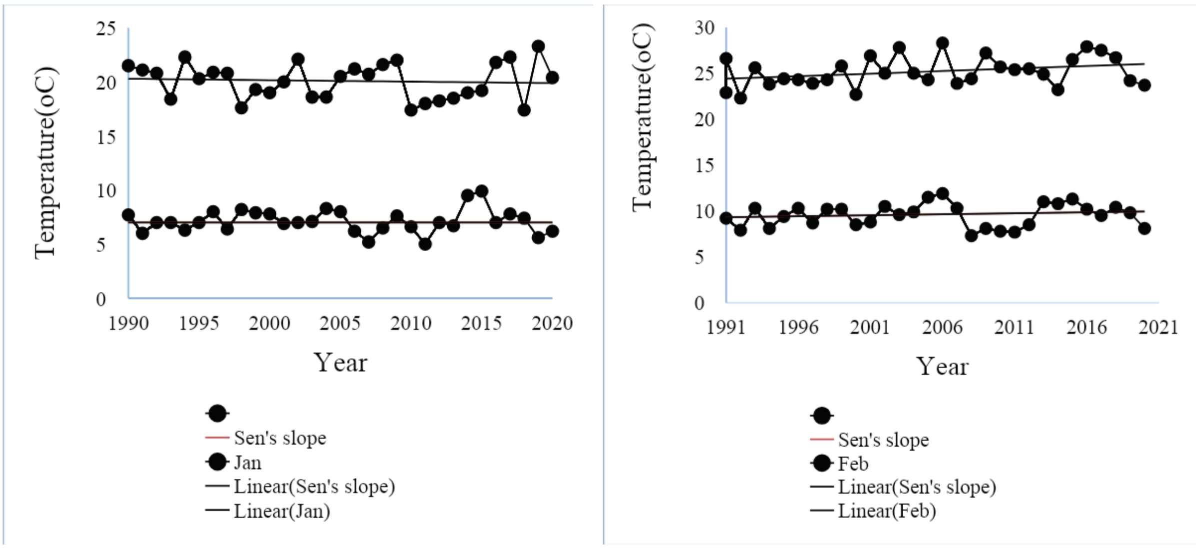


Fig. 5. Trend of average minimum and maximum temperature during 1990-2020 periods in Tikapur for winter (November-February), respectively

Source: DHM, Mid and Far Western Regional Climate Office, Surkhet

Trend of changing rainfall

The decreasing trend of total annual, monsoon and winter rainfall was recorded over 3 decades (Fig.6). The total annual rainfall decreased by 3.52 mm/year with the highest recorded rainfall of 2313 mm in the year 1997 and the lowest of 964 mm in 2019. Similarly, monsoon rainfall trend decreased by 2.92 mm/year with the highest recorded rainfall of 1961 mm in the year 2007 and the lowest of 735.3 mm in 2019. Further winter rainfall trend decreased by 0.65 mm year^{-1} with the highest recorded rainfall of 288.6 mm in the year 2013 and the lowest of 10 mm in 2016. However, all the trends are statistically non- significant at the 95% level.

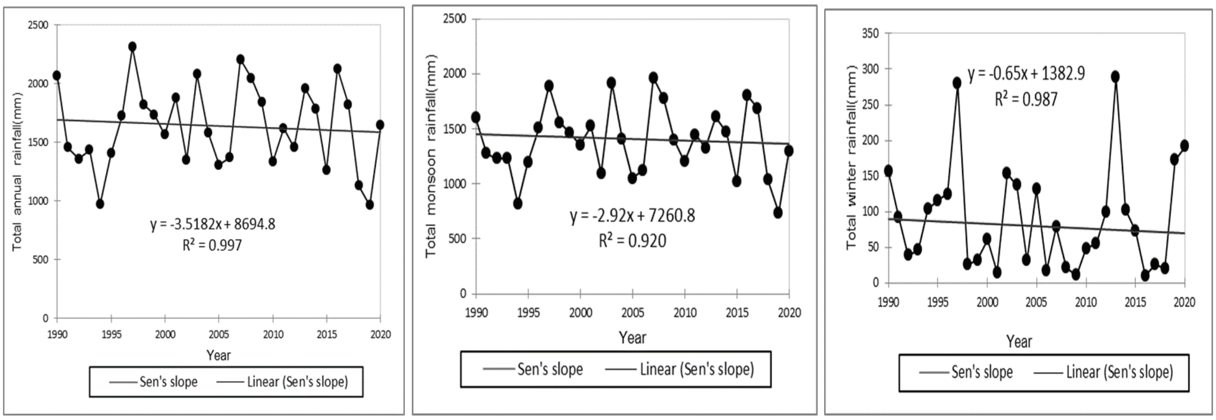


Fig. 6. Trend of total rainfall; annual, monsoon and winter seasons, respectively during 1990-2020 periods in Tikapur

The current study on Tikapur Municipality, meteorological data supports farmer's perceptions well when it comes to temperature and precipitation. Most perception based studies show that local peoples' perception matches with the trends of temperature and precipitation (Maddison, 2006, Timilsina-Parajuli et al 2013, Devkota, 2014). This is because people are good observers of their local environment who can recognize and interpret alteration taking place in their surroundings, which can have significant importance in shaping collective response to climate change. However; change in climatic factors, its impacts and perception at different regions of the country still need to be documented (Shrestha et al., 2012).

As temperature and rainfall are considered two major climate change indicators, people's perception revolves around these parameters. The majority of rapeseed growing farmers of Tikapur Municipality reported the increasing summer temperature, shorter and warmer winter in the area over the decades, whereas very few reported their experience of cooler winters. The previous studies on people's perception on climate change in the country from hills, mountains and terai has also given the similar responses to this study. In Kailali district, Thapa et al., (2015) reported the increasing temperature. Similarly, Chaudhary and Aryal (2009) reported the warmer winter especially in January and February in hilly regions of Eastern Terai. Studies in different socio-ecological settings across the country, people agreed on hotter summers, less chillingful warm and shorter winters (Chapagain et al., 2009). Similarly, the majority of local people have experienced irregular patterns of rainfall and decreasing winter rainfall but 30% responded to the increasing annual rainfall, which are in line with perception from Lamjung in the study of Joshi et al. (2019), where the majority of them reported an increase in erratic rainfall frequency but decrease in frequency of overall rainfall. The similar results were found in Rupandehi district (Manandhar et al., 2011; Sujakhu et al., 2016). People also observed prolonged no rainfall for a certain period with sudden heavy rainfall around different places in the country Chaudhary & Aryal (2009). These aspects are fundamental to identify local and global contexts, as well as for formulating generalized theory around how people respond to evolving surrounding and associated risks (Crona et al., 2013).

In the research area, more than half of the farmers had changed sowing dates due to an uncertain onset and cessation of rainfall. Farmers also used balanced fertilizers, added irrigation and switched local variety to respond to the changing climate. Similar to this, most respondents in Chitwan described changing the agricultural calendar, i.e., depending on the timing of rainfall for crop plantation (mainly paddy), followed by those in Dhading and then in Sindhupalchowk (Karki et al., 2020; Acharya et al., (2021) also reported different adaptation practices such as adjustment in planting time, changing crop varieties, conservation agriculture practices and traditional way of using Farm Yard Manure (FYM) mostly practiced by farmers of Puranchaur, Kaski. However, some of the farmers in Tikapur did not use any kind of adaptation measures and mentioned the lack of financial and technical resources and unawareness regarding climate change issues for doing so. The studies in Nepal and the Hindu-kush Himalaya region have also identified a lack of information and access to information and technology, and institutional frameworks as major factors limiting adaptation (Regmi & Bhandari, 2013).

Effect of sowing dates on yield and yield attributing characters

The sowing date significantly influenced rapeseed growth and yield components in the study area. Plant population varied significantly among sowing dates ($p < 0.05$), with higher populations observed in crops sown during the first and second fortnights of Ashwin compared to late sowing in the first fortnight of Kartik. Late sowing likely resulted in reduced and uneven plant establishment due to suboptimal soil moisture and lower soil temperature during germination (Mondal et al., 2011; Yadav et al., 2017). Although the number of primary branches per plant did not differ significantly among treatments, the number of siliques per plant declined significantly under late sowing ($p < 0.05$). This reduction can be attributed to a shortened vegetative growth period, which limits canopy development and assimilate production, and increased exposure to terminal heat and moisture stress during flowering and pod development, leading to poor flower retention and reduced pod set (Angadi et al., 2000; Kumar & Yadav, 2018). Consequently, seed yield differed significantly among sowing dates ($p < 0.05$), with the highest yield recorded in crops sown during the first fortnight of Ashwin, followed closely by the second fortnight of Ashwin, while the lowest yield was obtained from late sowing in Kartik. Similarly, test weight was highest under timely sowing and lowest under late sowing, indicating that delayed planting shortened the seed-filling duration and restricted assimilate translocation to developing seeds (Kumar et al., 2016; Tripathi et al., 2013). Overall, the combined effects of reduced plant stand, lower silique number, compressed grain-filling period, and increased thermal and moisture stress explain the yield decline under late sowing, emphasizing the importance of timely sowing for rapeseed productivity in the western Terai.

Table 1. Effect of sowing dates on major yield attributes of rapeseed at Tikapur during 2020-21

Treatments	Plant population	Primary branches/plant	Sec. branches/plant	No. of silique/plant
T1	130.55±22.87[a]	1.77±0.18[a]	2.76±0.35[a]	83.48±13.66[a]
T2	135.77±28.82[a]	1.85±0.24[a]	2.40±0.40[b]	76.01±9.37[ab]
T3	99.55±21.04[b]	1.88±0.23[a]	2.35±0.35[b]	66.46±6.44[b]
CV %	23.38	8.77	12.22	15.232
F- test	*	NS	*	*

Note: * = significant at 5% level of significance, NS= non-significant

Table 2. Effect of sowing date on seeds, yield and test weight

Treatments	No. of seeds/ silique	Yield (kg/ha)	Test wt (g)
T1	13.98±2.19[a]	1046.70±88.97[a]	3.30±0.35[a]
T2	14.42±2.46[a]	1044.28±88.92[a]	3.45±0.49[a]
T3	14.59±1.82[a]	1000.30±74.27[b]	3.10±0.35[a]
CV %	1.75	3.32	7.815
F- test	NS	*	*

Note: * = significant at 5% level of significance, NS =Non significant, CV=coefficient of variation; Differences were tested using F-test

The higher seed yield obtained in early sown crops may be due to adequate rainfall during sowing and seed germination time and also due to optimum temperature during vegetative and reproductive phase of the crop. (Fathi et al., 2003; Ranabhat et al., 2021) also agreed that higher seed yield in early sowing is due to longer reproductive phase. Manly owing to the variation in temperature or attributed to more light, water and mineral absorption by plant canopies thus, increasing photosynthetic capacity. Likewise, the lowest test weight in delayed sowing may be due to a shorter time for grain filling. A decreasing trend was recorded from the earliest date of sowing to the last date in agreement with (Chauhan et al., 2007) in Rayo.

CONCLUSION

This study demonstrates that climate change in Tikapur Municipality is characterized by declining rainfall and rising summer maximum temperatures, trends that are consistent with farmers' perceptions and directly relevant to rapeseed production. The concurrence between long-term climatic trends and local observations confirms that farmers' experiential knowledge reliably reflects ongoing climatic changes and can inform practical adaptation strategies. Reduced and erratic rainfall, together with increasing thermal stress, has increased uncertainty in crop establishment and shortened the effective growing period for winter crops such as rapeseed. Under these conditions, sowing date emerged as a critical management lever influencing crop performance. On-farm experiments showed that timely sowing during the first fortnight of Ashwin allowed rapeseed to exploit favorable soil moisture and temperature regimes, resulting in better plant establishment, higher silique number, improved seed filling, and ultimately higher yield compared to late sowing. Conversely, delayed sowing exposed crops to terminal heat and moisture stress, leading to yield penalties. Overall, the findings highlight that adjusting sowing dates is a low-cost, farmer-driven, and climate-responsive adaptation option that can buffer the negative impacts of warming and declining rainfall on rapeseed productivity in the western Terai. Future adaptation planning should therefore prioritize locally optimized planting calendars, supported by seasonal climate information and farmer engagement.

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AUTHOR CONTRIBUTIONS

Author A: Methodology, data curation, Formal Analysis, Writing-Original Draft, editing
Author B: Conceptualization, Methodology, Supervision, Writing- Review and Editing
Author C: Supervision, Writing- Review and Editing

CONFLICT OF INTEREST

We confirm that this manuscript has not been published previously and is not under consideration for publication elsewhere. All authors have read and approved the manuscript and have no conflict of interest to declare.

ETHICS APPROVAL

The study did not require formal ethical approval as it involved minimal risk and collected only anonymized data. However, informed consent was obtained from all participants prior to data collection. Participants were informed about the purpose of the study, and their confidentiality and anonymity were assured.

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