ИССЛЕДОВАТЕЛЬСКИЕ СТАТЬИ

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IMPACT OF CLIMATE CHANGE ON PHENOLOGY OF *Rhododendron arboreum* Sm., *Myrica esculenta* Buch.-Ham. ex D. Don AND *Alnus nepalensis* D. Don

M. Panta[1], R. A. Mandal[2]

[1] *Lord Buddha College*
Tokha Muncipality-15, Mahadevtar, Kathmandu, Nepal

[2] *Pokhara University, School of Environmental Science and Management*
Devkota Sadak, Mid Baneshwor, PO Box 2453, Kathmandu, Nepal

E-mail: manojpanta1994@gmail.com, ram.mandal@gmail.com

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This study was objectively carried out to show the trend of climatic variables to determine the effect of climatic variables on seasons and assess the response of phenology of a tree rhododendron *Rhododendron arboreum* Sm., kaphal *Myrica esculenta* Buch.-Ham. ex D. Don and the Nepalese alder *Alnus nepalensi*s D. Don at Bakte, Devithan and Nagarkot forests of Kavreplanchok district, Nepal. Climatic data such as rainfall and temperature from 1947 to 2016, were collected. Maps of selected sites were prepared and stratified into tree rhododendron, kaphal and Nepalese alder block. Altogether 60 samples having 10 × 10 m were collected from different directions (South, North, East and West). The diameter and height of seedlings were recorded and temperature was registered between February 18 to March 15, 2018. The total of 50 households was surveyed to get familiar with the ideas about climate change and its impacts on phenology. The result showed the highest average annual temperature around 17.41 °C in 2012, while rainfall was recorded highest about 2345.5 mm in 1985. The estimated highest monsoon temperature was 22.61 °C in 2012 and the lowest 8.93 °C in winter 1997. The (1947–2016) winter rainfall shows increasing by 0.05 mm but monsoon rainfall is decreasing by 2.99 mm annually. Direct measurements of temperature for 26 days showed the highest 26.5 °C on March 14 and the lowest 21.8 °C in February 18, 2018. The highest number of flowers of tree rhododendron and kaphal was found in southern aspect. The flowering started 15–30 days earlier its normal date, which was also confirmed by local people. Height growth of seedlings of tree rhododendron was 1.5 cm at southern aspect. This research will be useful for science community and policy makers.

Keywords: *temperature, rainfall, season, monsoon, growth, height, flowering, fruiting, forest vegetation, phenology dynamics, Nepal.*

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INTRODUCTION

Climate change is related to the change in the state of climate that can be identified due to the changes of mean values and the variability of its properties persisting for an extended period, typically for three decades or longer (IPCC…, 2015). Globally averaged combined land and ocean surface temperature data show a warming of 0.85 (0.65 to 1.06) °C over the period of 1880 to 2012. The six countries of South Asia – Nepal, Bangladesh, Bhutan, Maldives, India and Sri Lanka are facing serious problem regarding climate change (Zeppel et al., 2014). During the past century, warming up of about 0.75 °C has been observed. Nepal's average annual temperature rose at the rate of 0.03–0.06 °C between 1997 and 2005, with higher rate in mountainous than in low land (Gurung, Bhandari, 2009; MoEP…, 2010). The climate of Nepal is warming at lower rate compared to the global average of 0.74 °C per decade recorded in the twentieth century (Yang et al., 2017). The irregularity of climatic conditions has increased the risk of flood and drought, which have a direct effect on agriculture, forestry and other natural resources of South Asia (Walther et al., 2002; Schmitz et al., 2003; Tylianakis et al., 2008).

The plants' phenology is the most important characteristics of the plants, which have altered due to climate change (Yang, Rudolf, 2010). Specifically, the phenological characteristics like flowering, fruiting, leaf shading, sprouting, growing, reproduction, pollination, germination, etc. are affected because of the changes in temperature and rainfall (Visser, Both, 2005; Navarro-Cano et al., 2015) according to space and time. Higher altitudinal variations over short distance and rapidly increasing climate changes are making the situation tough for Nepal. The impacts of climate change are vivid in least developed, landlocked, and mountainous country. Nepal is also highly affected by climate changes because of hilly and sloppy terrain. The hilly slope aspect causes a high response to temperature variations. In fact, temperature is the most responsive parameter to climate change impacts. Any changes in temperature cause the shifting of plant phenology and growth (Zhang, Liu, 2012; Rai, 2015). The growth is related to the changes of diameter and height of the plant, while the reproduction is connected with flowering and fruiting period.

At the present there exists convincing evidence of climate change. Media report the news related to the changes of phenological characteristics of *Rhododendron arboreum* Sm., *Myrica esculenta* Buch.-Ham. ex D. Donand *Alnus nepalensis* D. Don in Nepal. However, the studies to showing the phenological dynamic of the plant species are limited. Therefore, this research was carried out to show the trend of climatic variables (rainfall and temperature), estimate the effect of climatic variables on seasons and assess the response of phenology of *Rh. arboreum*, *M. esculenta* and *A. nepalensis* due to climate change.

MATERIALS AND METHODS

Study area. This study was conducted at three different forest sites, namely ThuloLek CF, Gakhureshwor CF, and Shree Daura Bishauna CF in Kavrepalanchowk district, Nepal. This district is located between 85°24′ to 85°49′ E and 27°31′33.24″ N. Mean annual temperature vary from 9 °C (winter) to 28 °C (summer). The average annual rainfall is ranging from 1300 to 2687 mm depending on the sites. The district covers an area of 1404.86 km² (Fig. 1).

Data collection methods. Both primary and secondary data were collected. Primary data include field records, samples and household survey while the secondary data include the climatic variables and literature. The map of the study site was prepared and stratified based on the species dominancy particularly *Rh. arboreum, M. esculenta* and *A. nepalensis* (Fig. 2–4).

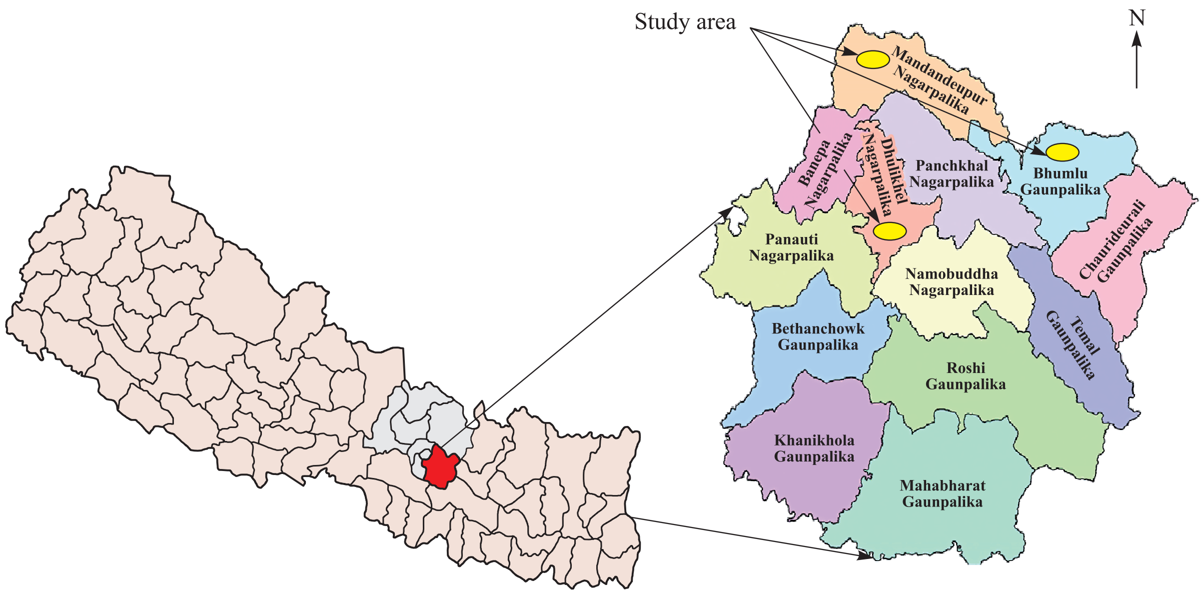

Fig. 1. Map of study area.

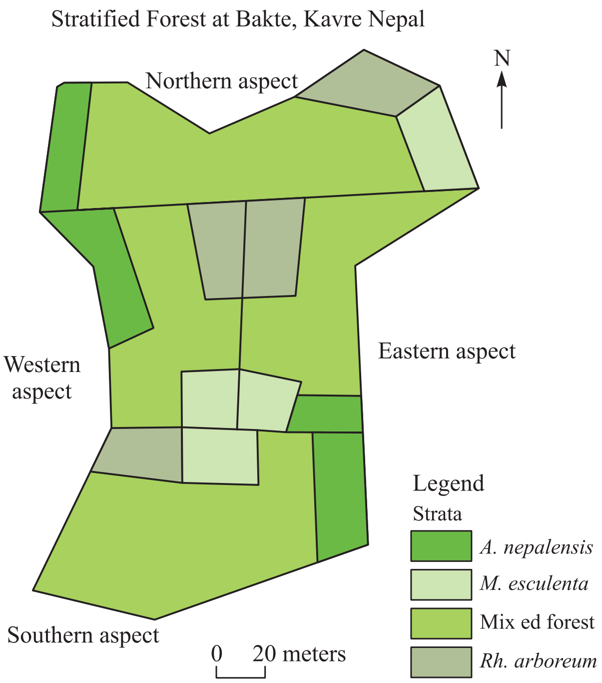

Fig. 2. Aspects in Bakte, Kavre, Nepal.

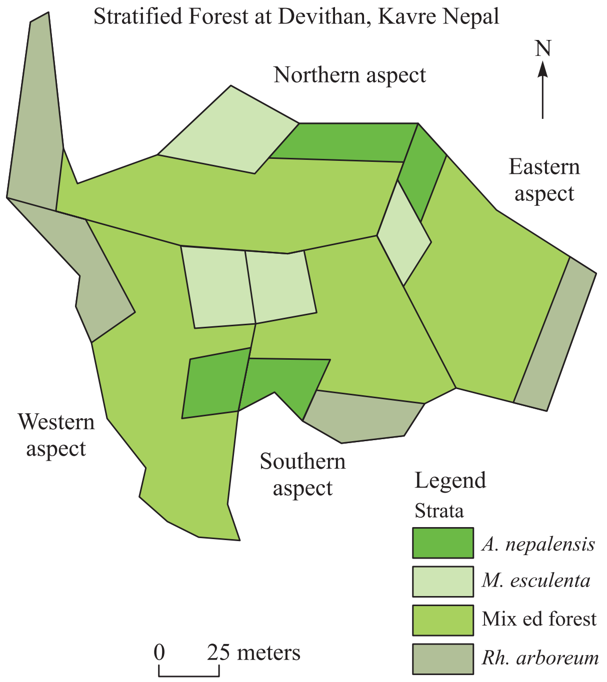

Fig. 3. Aspects in Devithan, Kavre, Nepal.

Altogether 60 sample plots having 10 × 10 m were established in the field. Specifically, five plots in each aspect (South, North, East and West) were established to collect the data. Two series of observations were carried out particularly between 12 to 15 February, and between 19 to 23 March, 2018. The observations were focused on recording the phenology of flowering, fruiting, seed falling, leaf falling, sprouting including seedling growth measurements, pest and disease occurrence and their samples collection, species composition and distribution, etc. The photographs of budding and flowering were taken on 19 February 2018 from southern and eastern aspect, while another photograph were taken on 20 February, from southern and western aspects. The photographs of diseased and infected leaves, bark, buds, flowers, etc. Were made in the field. Moreover, relevant examples demonstrating phenology from books, journals, articles, magazines, internet papers, newspapers, research publications, etc. were collected (Jackson et al., 1994; Kayastha, 2002). In addition, the rainfall and temperature data of Dhulikhel station collected from the Department of Hydrology and Meteorology (DHM) are used to analyze the climatic pattern, such as rainfall since 1947 to 2016 and temperature since 1987 to 2016. Besides, aspect-wise daily temperature was also recorded for 26 days (18 February to 15 March, 2018) in the field using temperature recorder.

All together 50 households were surveyed to collect the ideas on climate change and its impact on flowering, fruiting, leaf shading, sprouting season etc. The respondents were, in general, more than 50 years old and information was collected from their own experience. Additionally, a group discussion was conducted to gather information regarding the changes in forest development, changes in phenological characteristics, etc.

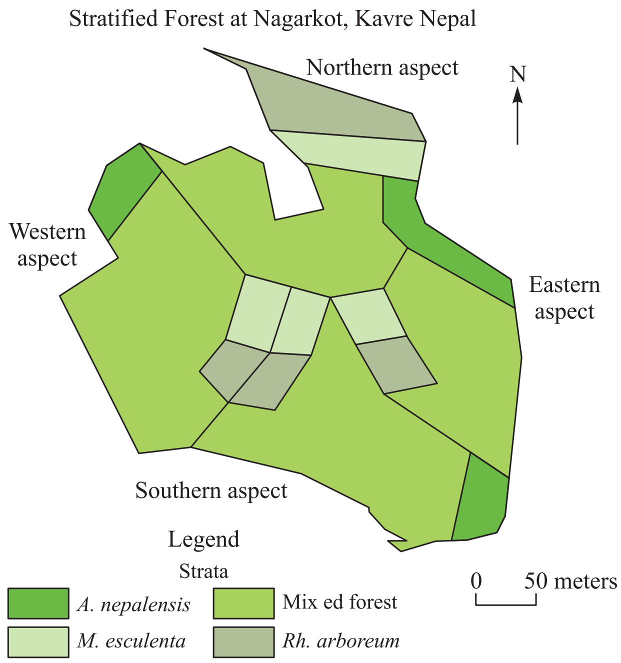

Fig. 4. Aspects in Nagarkot, Kavre, Nepal.

Data analysis. The collected data were analyzed using descriptive and inferential statistics. The trend analysis was made to show the variation in temperature and rainfall. The responses of the observers were related with the observed climatic data. The aspect-wise variation in phenology of the plants was compared with literature to find the temporal shifting in present phenology of plants. Photographs of diseased infected samples were matched with available information and photographs from Google engine. In addition, expert consultations were recorded to identify diseases and pests in the plants.

RESULTS AND DISCUSSION

Climatic data analysis for assessing climate change. The average temperature and total rainfall varied according to the time period. The result shows the increasing trend of average annual temperature. Particularly, it was the highest around 17.41 °C in 2012, while the rainfall was very low (nearly 916.6 mm). The highest rainfall was recorded about 2345.5 mm in 1985, while the average annual temperature was as low as 16.63 °C (Fig. 5).

The highest rainfall was recorded in 1985 with 2345.5 mm and this year average annual temperature was 16.63 °C (less) it was minimum in 2012, with 916.6 mm and the average annual temperature being the highest around 17.41 °C. The above figures show that the average annual temperature was the highest in 1999 and total annual rainfall was the lowest in 2012. The variation in temperature and rainfall will have obvious effect on the phenology of the plants.

Comparison of winter, pre-monsoon, monsoon and post-monsoon seasonal rainfall. As far as rainfall and temperature are concerned, there are four seasons in Nepal. Specifically, December, January and February are winter months in Nepal, which is the coldest and most dry season. March to May months are considered as pre-monsoon season when the thunderstorms are common. June to September months are monsoon (rainy) season, while October and November months are the post-monsoon season.

Seasonal rainfall of Dhulikhel. The records of winter rainfall were positively correlated with the year, though R^2 was much less – 0.001. The highest winter rainfall was recorded and amounted to 160 mm in 1962. The correlation between annual pre-monsoon rainfall vs year shows positive correlation, with R^2 equal 0.005. It was the highest rainfall, which was recorded around 430.2 mm, but it was the lowest (about 40.4 mm) in 2002 and 1954, correspondingly. The monsoon rainfall was decreasing between 1947 to 2015. The correlation between rainfall vs year was 0.047. The highest rainfall was recorded in 1954 (2131.2) and in 2013 (677.4 mm). The annual rainfall of post-monsoon period was negatively correlated with the year as R^2 was equal to 0.011. The highest rainfall was recorded in 1985 (about 271.7 mm) which was followed by 264.4 mm in 1999. The pre-monsoon and monsoon rainfalls were very changeable compared to the rainfall of other seasons (Fig. 6).

Seasonal annual average temperature of Dhulikhel. The temperature varied according to seasons. The highest average annual temperature 22.61 °C was recorded in 2012, while the lowest temperature 8.30 °C was recorded in 2015 (Fig. 7).

The average annual temperature records were quite static in monsoon season, while there was a dramatic variation in temperatures of other seasons. The diverse temperatures are the indicators of strong influence on plant phenology.

Summary of seasonal temperature and rainfall of Kavreplanchok. The summary records of temperature and rainfall show that there was a correla-

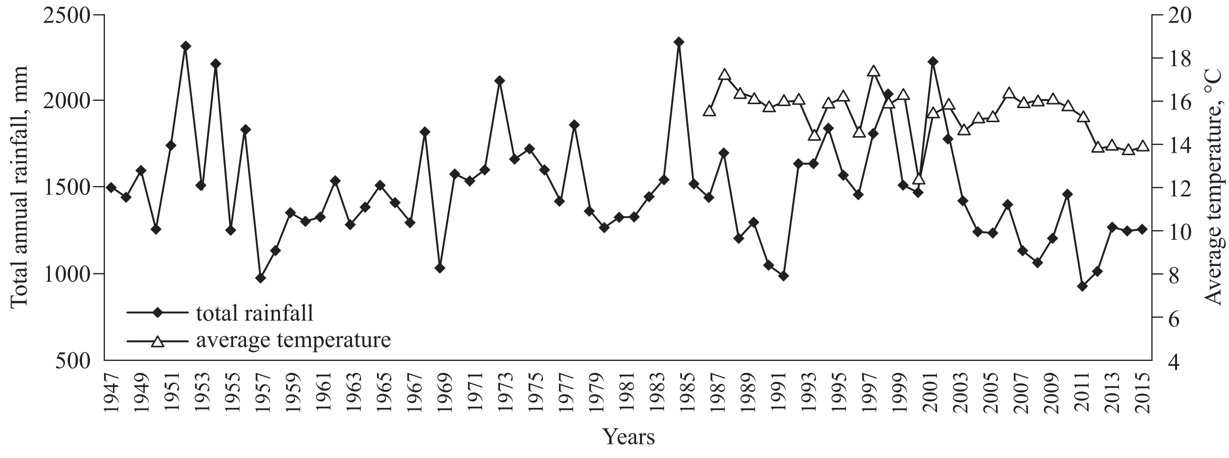

Fig. 5. Temperature and rainfall variation.

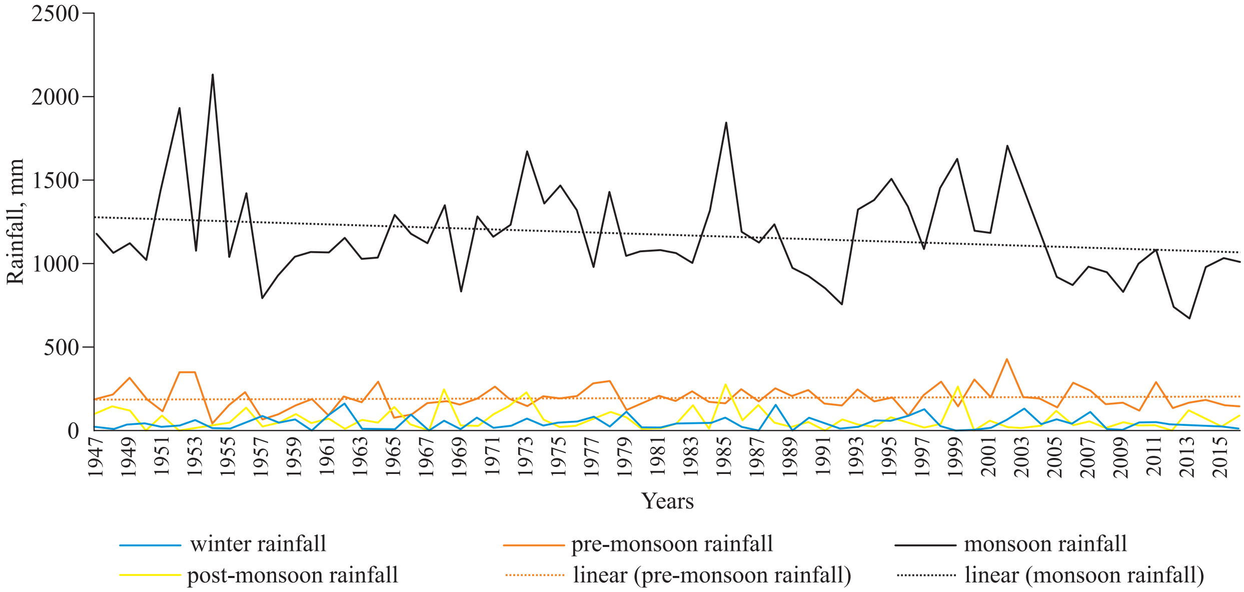

Fig. 6. Seasonal rainfall variation.

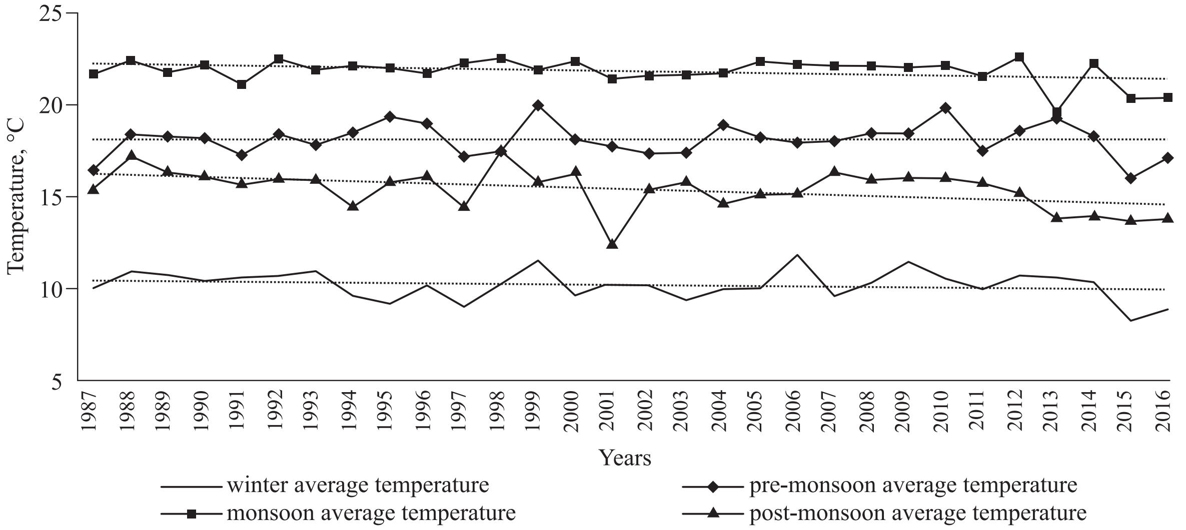

Fig. 7. Variation in temperature according to seasons. Dotted lines shows linear equilizing finctions.

tion of time periods with temperature and rainfall. The average annual temperature records before 2012 positively changed and the same results were found for rainfall (Table 1). The estimated highest monsoon temperature was 22.61 °C in 2012 and the lowest (8.93 °C) in winter of 1997.

Phenological dynamics of plants *Rh. arboreum*, *M. esculenta* and *A. nepalensis*. The temperature recorded in Dhulikhel at 12 : 30 pm between 18 February to 15 March, 2018. Fig. 8 shows 26 days (18 February to 15 March, 2018) temperatures at 12:00 noon. The highest daily temperature was recorded around 26.5 °C on 14 March, 2018 and the lowest daily temperature was 21.8 °C on 18 February, 2018.

Aspect-wise temperature variation. The temperature also varied according to the aspect. The highest daily temperature around 16.8 °C was recorded at southern aspect, but it was the lowest (12.6 °C) at Northern aspect (Fig. 9).

Phenological dynamics of Rh. arboreum, M. esculanta and A. nepalensis based on literature and observations of residents. The time shift was recorded in phenology of *Rh. arboreum*. Early flowering of *Rh. arboreum* was observed one month earlier. The observations of people and field data on fruit ripening of *M. esculenta* differed from the previous data in literature. The fruit ripening period was shifted about 15 days earlier compared to the past period (Table 2).

Table 1. Seasonal average annual temperature and rainfall variation

Climate parameter	Highest record & Year		Lowest record & Year		R^2	Correlation
	Average annual temperature, °C (records till 2012)					
Overall	17.8	1999	16.19	2001	0.006	+ ve
Winter	11.83	2006	8.93	1997	0.001	+ ve
Pre-monsoon	19.98	1999	16.4	1987	0.049	+ ve
Monsoon	22.61	2012	21.09	1991	0.014	+ ve
Post-monsoon	17.35	1998	12.38	2001	0.031	– ve
	Annual rainfall, mm, till 2016					
Annual rainfall	2345.4	1985	916.6	2012	0.037	– ve
Winter	160	1962	–	–	0.001	+ ve
Pre-monsoon	430.2	2002	40.4	1954	0.005	+ ve
Monsoon	2131.2	1954	677.4	2013	0.047	– ve
Post-monsoon	271.7	1985	–	–	0.011	– ve

Note. Lowest value of rainfall is not recorded since records were 0 mm.

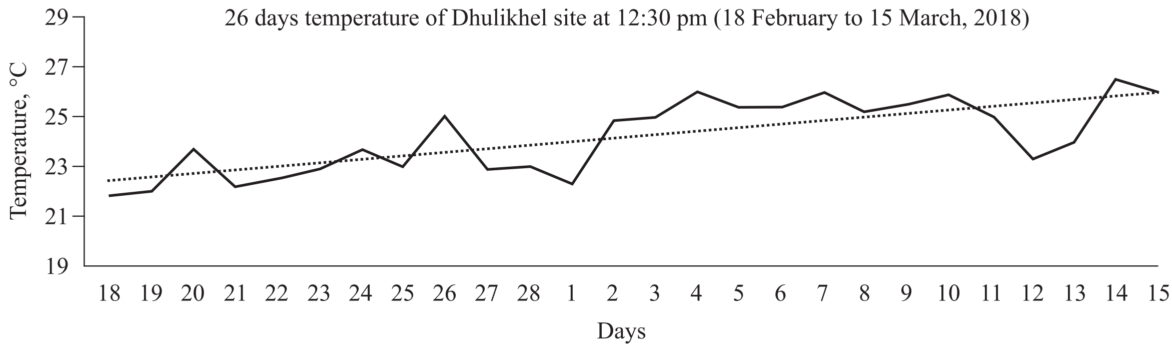

Fig. 8. Observed temperature reading of Dhulikhel, Kavreplanchok.

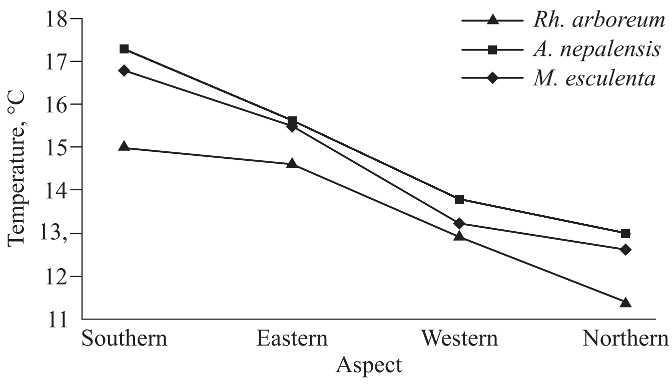

Fig. 9. Aspect wise temperature variation.

Aspect-wise variation of plant phenology. The phenology of *Rh. arboreum* also varied according to the aspect. The south aspect is the warmest in the mountains so it showed the earliest flowering and seeding and seedling growth. The field observations show the variation in temperature according to the aspect (Table 3).

Daily temperature was the highest (around 20.3 °C) at the south aspect, which was followed by about 18.9 °C at the east aspect. The start of flowering was observed at the east aspect, while full blossoming was recorded at the south aspect (Fig. 10, *a*–*d*).

Association of plant species. *Pinus roxburghii* Sarg. is frequently found in hot and sunny places of subtropical altitudinal range. During field observations it was associated with plant *Rh. arboreum,* while *Rhododendron* L. was generally found in temperate zone of Nepal.

Table 2. Plant phenology based on literature and observations of residents

Phenology	Observations of residents		Literature data		Difference
	Starting date	Final date	Starting date	Final date	
Phenology of *Rh. arboreum*					
Leaf falling	Regular changes of leaves over the year		Evergreen species	Evergreen species	
Sprouting	Just the same	–	Just the same	Just the same	
Budding	1st week of January	–			
Flowering	29 January	15 April	March, 1	End of May	1 month
Fruit ripening and maturity	1st week of March	End of April	August–March	August–March	
Phenology of *M. esculenta*					
Leaf falling	Regular changes of leaves over the year	–	Evergreen species	Evergreen species	
Sprouting	Just the same	–	Just the same	Just the same	
Flowering	15 February	15 March	Not found	Not found	
Fruit ripening & maturity	15 April		Last week of April	Last week of July	15 days
Phenology of *A. nepalensis*					
Leaf falling	February	March	Not found	Not found	
Sprouting	Fagun (March)	April	Just the same	Just the same	
Flowering	1 October	16 October	Last week of October	Last week of Novemder	1 month
Fruit ripening & maturity	November	December	December	January	1 month

Table 3. Aspect-wise effect of plant phenology in Bakte, Kavre

Phenology of *Rh. arboreum*	Aspects			
	North	West	East	South
Budding	Delay	Earlier than in the north	Earlier than in the north and west	Earlier than in the north and west
Flowering	Delay	Just the same	Just the same	Just the same
Seedling growth	Slow	Faster than in the north	Faster than in the north and west	Faster than n the north and west
Insect and pest occurrence	Low	Low	Higher than in the north and west	Higher than in the north and west
Common insect & pest name	Fungi, defoliator			
Infected parts	Leaf, stem, shoot, flower.			

Local people stated that 10 years before there was no *P. roxburghii* at that location, it was observed just 200–300 m below the site though now it shifted in the upward direction, especially at southern aspect. They remark there was an increase in vegetation density and composition. There appeared, namely, *P. roxburghii, Schima wallichii* Choisy, *A. nepalensis, Quercus* L. spp., *Rh. arboreum, M. esculenta and Castanopsis indic*a A. DC.

Aspect-wise seedling growth. The growth performance of *Rh. arboreum, A. nepalensis* and *M. esculenta* varied according to aspect (Amatya et al., 2016).

First measurements were conducted from 12 to 15 February, 2018 and second measurements of the same plants were made from March, 19 to 23, 2018. The height growths of seedlings of *Rh. arboreum* were 1.5, 1.2, 0.8 and 0.7 cm at southern, eastern, western and northern aspect, respectively, within 35 days. The diameter growths of *Rh. arboreum* were 0.2 for each in the South and East aspects. The height growths of seedlings of *A. nepalensis* were 6 cm, 8.3 cm, 7.6 cm and 4.1 cm at southern, eastern, western and northern aspects, respectively, while that of diameter was the highest (0.5 cm) at southern aspect. The height growths of *M. esculenta*

Fig. 10. Aspects of *Rh. arboreum* flowering in Kavre: *a* – bud sign, records from North aspect, Bakte; *b* – bud, records from West aspect, Nagarkot; *c* – blooming, records from East aspect, Kosipari; *d* – flowering, records from South aspect, Bhumlu.

seedlings were 2.4, 1.8, 1.6 and 1.2 cm at southern, eastern, western and northern aspects, respectively, while the highest diameter growth was 0.3 cm in the south aspect (Table 4).

Dynamics of climatic variables. Temperature and rainfall are the main climatic variables that we used for the identification of climatic variation. The trend of average temperature has been increasing while it was decreasing in annual rainfall. It shows the decreasing trend of total annual rainfall (Kripalani, Kulkarni, 1997; IPCC…, 2007). Hence, these data ontemperature and rainfall agreed with the observations of residents during the field survey. Some literature data showed warming up and irregularity in rainfall. Globally averaged combined land and ocean surfacetemperature data indicate warming of 0.85 (0.65 to 1.06) °C over the period from 1880 to 2012 (IPCC…, 2014). Average temperature in Nepal raised at the rate of 0.03–0.06 °C per annum from 1997 to 1994 (Gurung, Bhandari, 2009). The atmospheric temperature and rainfall variations showed location and seasonal specificity. There were changes in rainfall patterns (high, low, and intensive rainfall), according to the seasons (IPCC…, 2014).

The rate of decreasing for monsoon and post-monsoon rainfalls was higher than that of increasing rate of winter and pre-monsoon rainfall, which showed that the rainfall was decreasing and the drier days were increasing. All seasonal temperatures were positively correlated with year except post-monsoon temperature till 2012. Winter, pre-

Table 4. Growth performance for seedlings of plants according to aspects

Aspects	Height, cm		Height growth, cm	Diameter, cm		Diameter growth, cm
	First observation	Second observation		First observation	Second observation	
Rh. arboreum						
North	50.5	51.2	0.7	2.5	2.5	0
South	69.3	70.8	1.5	3.7	3.9	0.2
East	73.5	74.7	1.2	4.5	4.7	0.2
West	48	48.8	0.8	3.6	3.7	0.1
A. nepalensis						
North	50.5	56.5	6	3	3.4	0.4
South	91	99.3	8.3	3.7	4.2	0.5
East	26.5	34.1	7.6	1.3	1.7	0.4
West	56.6	60.7	4.1	3.1	3.3	0.2
M. esculenta						
North	70	72.4	2.4	2.8	3.1	0.3
South	67.6	69.4	1.8	2	2	0
East	9.5	11.1	1.6	1.7	1.9	0.2
West	86	87.2	1.2	3.9	4	0.1

monsoon and monsoon temperatures was increasing by 0.003, 0.023 and 0.006 °C, respectively. From 2013 to 2016 there was erratic variation of temperature for all four seasons, since the temperature was increasing during that period. The seasonal temperature and rainfall data shifted from this particular season to that of the next, which may result in the seasonal variation from the previous and present seasons. Seasonal changes are caused by the tilting of the Earth, while the monsoon weather systems are due to the land-sea temperature differences caused by solar radiation (Huffman et al., 1997).

When the Earth rotates and revolves around the Sun, different seasons occur due to different land masses of the northern and southern hemispheres. Predicted temperature increase in the late 21st century and early 22nd century will cause frequent changes and shifts of the monsoon precipitation up to 70 % below normal levels (Schewe, Levermann, 2012). Not only will this affect the Indian summer monsoon, but the onset of monsoon over Southeast Asia may also be delayed up to 15 days in the future (Goswami, Mohan, 2001; Gadgil, 2003). Distributional changes in the monsoon and climate change extend to cause less precipitation in summer and a delay in the onset of the East Asian summer monsoon (EASM). On 24 July 2004, the scenario was different as northeastern India and Bangladesh showed an early monsoon onset and experienced maximum flooding that caused a death toll of approximately 1000 people across South Asia (Loo et al., 2015; Tejavath et al., 2017).

Phenology of plants. Due to the increasing trend of temperature in the southern aspect, there occur early flowering, fruiting, fruit ripening, etc. (Singh et al., 2016). We have found that flowering takes place a month earlier for *Rh. arboreum* than its previous calendar date, the flowering of *M. esculenta* also started earlier than its normal period. Diseases and pathogen attacks were also remarkably high at southern belt. Mostly leaf and bark of *Rh. arboreum* and *A. nepalensis* were affected by fungi, defoliators, etc. *M. esculenta* was also attacked by insects but to a lower extent. The ecological consequences are certain to occur due to climate change (Inouye, 2008). Such climate change manifestations have appeared in the Kumaun Himalayan region in the form of early flowering and fruiting of native trees, such as *Rh. arboreum* (Kumar, 2012; Gaire et al., 2014).

Relationship between forest vegetation and climate change. Plants live on atmospheric CO_2, get their food using CO_2 and sunlight during photosynthesis. Carbon amounts to about 50 % of plants' dry weight, forest soil stores largest amount of carbon in forest ecosystems and plants above soil level store about 20–30 % of carbon (IPCC…, 2014). Atmospheric carbon gets stored in plants, soil, grass and leaf litter. This carbon is emitted into atmosphere when forest products decompose or get destroyed by different processes. Emission rate of carbon in the process of deforestation (forest fire, felling) is greater than that of natural emission, which brings about climate change (The melting Himalayas…, 2007; IPCC…, 2007). Human activities in the forest (mainly deforestation and forest degradation) cause 17.4 % of greenhouse gas emission (IPCC…, 2007).

Carbon stock (amount) in the forest all over the worldis greater than atmospheric carbon stock. Therefore, efficient management of the forests can store more carbon than deforestation and degradation of forests release into the atmosphere. Most physiological processes in plants occur 0–45 °C. General optimum is 20–30 °C (or sometimes 12–35 °C) but this calendar is disturbed due to differences in temperature and rainfall (Hasanuzzaman et al., 2013). There occur changes of species habitat (Davis, Shaw, 2001). B. P. Kayastha (2002) described the home range of *Rh. arboreum* which was 1500 up to 3300 m altitudinal range, but the observations showed that its range is at lower alttude of 1372 m, i. e. the range is shifted.

CONCLUSION AND RECOMMENDATIONS

The total and seasonal temperature and rainfall are very irregular. The phenology especially flowering and fruiting periods of *Rh. arboreum, M. esculenta* and *A. nepalensis* were shifting and matching with the people's perception of early flowering, fruiting and ripening. The species association is also changing these days. The study will be useful for scientific community and policy makers to recognize the impacts of climate change, though intensive studies are required to further develop climate change science and phenology of the plant.

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ВЛИЯНИЕ ИЗМЕНЕНИЙ КЛИМАТА НА ФЕНОЛОГИЮ РОДОДЕНДРОНА ДРЕВЕСНОГО *Rhododendron arboreum* Sm., КАТПХАЛЫ *Myrica esculenta* Buch.-Ham. ex D. Don И ОЛЬХИ НЕПАЛЬСКОЙ *Alnus nepalensis* D. Don

М. Панта[1], Р. А. Мандал[2]

[1] *Колледж бога Будды*
Непал, Катманду, Махадевтар, Тоха Муниципалити-15

[2] *Похарский университет, школа наук об окружающей среде и менеджмента*
Непал, Катманду, а/я 2453, Девкота Садак, Мид Банешвор

E-mail: manojpanta1994@gmail.com, ram.mandal@gmail.com

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Данное исследование предпринято с целью установления тренда климатических изменений и выявления их влияния в разные сезоны года на фенологические реакции рододендрона древесного *Rhododendron arboreum* Sm., катпхалы *Myrica esculenta* Buch.-Ham. ex D. Don и ольхи непальской *Alnus nepalensis* D. Don на лесных участках Бакта, Девитан и Нагаркот Каврепланчокского района в Непале. Были собраны климатические данные об осадках и температуре с 1947 по 2016 г. Подготовлены и нанесены на карты отобранные участки произрастания рододендрона древесного, катпхалы и ольхи непальской. Всего их было выбрано 60 размером 10 × 10 м в разных местах, ориентированных на юг, север, восток и запад. Регистрировали диаметр и высоту сеянцев, а также температуру в период с 18 февраля по 15 марта 2018 г. Опрошено 50 домовладельцев для того, чтобы узнать их мнение о влиянии изменения климата на фенологию. Результат показал наивысшее значение среднегодовой температуры около 17.41 °C в 2012 г., тогда как наибольшее количество осадков (2345.5 мм) зафиксировано в 1985 г. Самая высокая температура муссонного периода составила 22.61 °C в 2012 г., а самая низкая (8.93 °C) – зимой 1997 г. Установлено, что количество осадков в зимний период с 1947 по 2016 г. ежегодно увеличивалось на 0.05 мм, а в муссонный период уменьшалось на 2.99 мм. Измерение температуры в течение 26 дней в 2018 г. показало, что самое высокое значение (26.5 °C) было 14 марта, а самое низкое (21.8 °C) – 18 февраля. Наибольшее количество цветков у рододендрона древесного и катпхалы обнаружено на пробных участках в южной части. Цветение отмечено на 15–30 дней раньше обычного срока, что также подтвердил опрос местных жителей. Прирост сеянцев рододендрона древесного составил 1.5 см на южных участках.

Ключевые слова: *температура, количество осадков, сезон, муссон, рост, высота, цветение, плодоношение, лесная растительность, фенологическая динамика, Непал.*