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Research article

Environmental policies to protect pollinators: attributes and actions needed to avert climate borne crisis of oil seed agriculture in Pakistan

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Abstract: The impact of climate change on oil seed crop is getting more and more pronounced with each passing day, resulting in reduced crop yields in Pakistan. Agriculture is the mainstay of Pakistan's economy, however it is subjected to severe climatic vulnerabilities like floods, droughts, and changing rainfall patterns. Climate change has a marked influence on the population and distribution of pollinators. Extreme weather events can further aggravate the situation by causing high overwintering losses. Less roving pollinators, such as small beetles and ground nesting bees, may be among the most severely affected by flooding and gusts. Extreme conditions not only can disrupt the livelihoods of individual insects, but can also negatively impact entire colonies or local populations. It is recommended to take offensive measures to address these issues, otherwise the area under oil seed crops may decrease resulting in poor market stability index. Moreover, in this regard, there is desperate need to aggressively explore opportunities of capacity building and institutional strengthening to address the climate change issues in Pakistan. Through this review, it is hoped that a proactive risk assessment approach to climate change can assist the Government in making strategies against the losses of pollinator services in Pakistan.

Keywords: oil seed crops; climate change; pollinator

1. Introduction

The livelihoods of millions across the globe are directly dependent on agriculture. In agricultural crop production, pollinators play a pivotal role, however, these are taken for granted and not given their due importance. Thousands of plant species depend on pollinators for pollination. Pollinator dependent crops contribute to the earnings of farmers and provide advantages to Agri-food businesses using pollinator products. Virtually 90% of plant species are pollinated by means of animals and hence the health of natural “ecosystems” are essentially related to the fitness of pollinators [1]. The fruits and seeds which result from animal pollination are vital sources of food for plenty of mammals, fowl, reptiles, and worms.

Pollinators constitute a central component of worldwide biodiversity, imparting essential ecosystem offerings to crops and wild vegetation. There is clear evidence of recent declines in both wild and domesticated pollinators, and parallel declines within the plant life that depend upon them [2]. Moreover, there is mounting evidence of pollinator decline all around the globe with extensive effects in many agricultural regions [3]. This decline in the relative abundance of pollinators and their diversity can cause marked decline in pollination services that would substantially affect the conservation of wild plant variety, wider ecosystem stability, crop yield, food security, and human welfare [4]. The associated issue of decline in the population of pollinators and its subsequent impacts on global health and nutrition are difficult to judge. Any effect is probably dramatic in developing nations that are already prone to food and nutrient shortages associated with demographic and climate change [5].

Global climate change is a change in long term weather patterns that characterize regions of the world. The term weather refers to everyday changes in temperature, wind, and/or precipitation of a region. Global warming is an unfolding phenomenon; an increase in the average temperature of the earth’s surface and of its oceans are due to high concentrations of greenhouse gases. The primary grounds of the high emission of greenhouse gases is the burning of fossil fuel and deforestation. Long term climate changes affect the amount and quality of crops in terms of growth rate, photosynthesis and transpiration rate. These changes directly have an impact on increasing the earth’s temperature, hence ultimately reducing the yield [6]. Pakistan has a mostly warm climate, and as a result is particularly vulnerable to climate change. Geographically, Pakistan lies in a region where temperature rises are predicted to be higher than the global mean. This rise in temperature causes global warming to increase the overall mean earth surface temperature and concentration of greenhouse gases. These changing climatic conditions have directly affected oil seed crops by decreasing the activity of pollinators [7]. It is expected that these climatic conditions may further diminish the yield down to 30% by 2050 [8].

Climate change affects the amount and class of food, and other ecosystem services. Mild warming (1–3 °C) is anticipated to benefit agriculture in mid to high latitudes, yet it may lower yield in low latitudes (medium confidence) [6]. The lack of ecosystem services is likely to be a principle result of climate change. Though ecosystems tend to adapt themselves to the changing climate, their resilience in current times is undermined by means of living and growing population of human race. Climate change also presents threats to pollination services [9]. Indeed, several authors have stated that the ecological effect of climate change effects pollination services [10,11]. These changes in the climatic conditions have caused decline in the production of oilseed crops in Pakistan. Future food production must therefore lessen its stress on ecosystems and plan for the unexpected circumstances; such as changes in freshwater, natural pest regulation and pollination services.

2. Adaptive policy measures taken worldwide

Researchers from the Wessex BESS consortium discovered that there had been a net decline in pollinating insects in Great Britain [12]. Insurance provided by biodiversity is weakened, leading to a higher risk of ecosystem function deficits. Sustainable urban areas, when planned and managed properly, can help in mitigating the effects of climate change with the aid of decreasing the ecological footprints related to food production. At the same time, urban agriculture can enhance climate change adaptation efforts by means of growing vegetation cover and lowering surface water run-off [13].

Greenspace in urban neighborhoods has a crucial role to work in assisting pollinators and offers a possibility for massive numbers of people to have contact with and benefit from biodiversity. Remodeling some of the grasslands to annual and perennial meadows helps pollinators and other useful invertebrates throughout the year [14]. Research work carried out by Dicks et al. [15] argued that presenting flower-rich habitat for 2% of farmed land and 1 km of flowering hedgerow in line with 100 ha can supply those species with sufficient pollen to feed their larvae (at low estimates of pollen demand). Santangeli et al. [16] proposed that there are numerous farmland conservation efforts that can be economical for farmers and may be implemented voluntarily without financial incentives. These consist of growing uncultivated margins around arable fields and nest containers for solitary bees.

The composition of species communities are changing rapidly through drivers such as habitat loss and climate change, with potentially serious consequences for the resilience of ecosystem functions on which humans depend [17-20]. The management of a pollinator variety entails many stakeholders and frequently implies transfer of prices and advantages among stakeholder corporations. It is therefore critical that mechanisms be evolved not only to seek advice from stakeholder corporations, but additionally to facilitate their authentic participation in the process of decision making and sharing of benefits [21].

This paper discusses simple adaptation and potential approaches that could help reduce the effect of climate change on pollinators' health and activity which may eventually redeem oil seed agriculture in the country. We believe that this review will help the scientists, researchers, planners and policy makers devise future strategies for climate change impact assessment and adaptation for the protection of pollinators to avert agriculture crisis in Pakistan.

3. Climate change impacts on oil seed crops

The world oilseed market has shown a downward trend for the last few years, which has also affected the local market of oilseeds/edible oil. Pakistan produced 0.462 million tons of edible oil during 2015–16 and 2.8 million metric tons were imported from other countries during the aforementioned years. This import was 12% more than the previous year (Table 1). Oils and fats are very important constituents of the human diet. These oils can be extracted from several types of harvests. More than a dozen oil seed crops are grown in Pakistan, but rapeseed and mustard are the major ones. Rapeseed and mustard are good sources of edible oil and contain 44–46% oil; additionally its meal contains 38–40% protein. In Pakistan, domestic edible oil production is very low, so these requirements are fulfilled through import from other countries. One of the factors accountable for low productivity of oilseed crops is the failure of seed setting at the appropriate time due to lack of pollination [22-26]. Among the diverse pollinating agents, insect pollinators play a fundamental role in increasing the production of oilseed crops [27]. Essential oil crops that need pollination interventions for reinforcing productiveness are rapeseed, mustard, sunflower, safflower, sesame, niger, taramira, and linseed. There is substantial evidence for decline in pollinator populations because of degradation in the ambient environments [28]. Current declines in both wild and domesticated pollinators, and parallel declines in the flora which depend on them, constitute a critical risk to global food security and sustainable agriculture [29].

The timing of pollination is decided by means of climatic cues which include temperature and water availability [30]. Many pollinators additionally synchronize their life cycles with climatic cues, and this phenological response of flora and pollinators needs to stay widely synchronized for many plant-pollinator relationships to remain feasible. Climate change is altering the phenological response of flora and a few pollinators may be unable to adjust their life cycles in synchronization with altered pollination timing. Kudo et al. [31] showed that, since 1998, plants have been flowering much in advance in alpine environments whilst the time of the emergence of pollinators has not adjusted appropriately in response to the climatic changes, thereby disrupting pollination. Climate change additionally shifts the latitudinal and altitudinal climate "envelope" of species. Some species are more mobile or adaptable to change, therefore the composition of plant and pollinator assemblages is likely to vary in many placements. For instance, species within the tropics are close to their thermal maxima, hence environmental warming causes a few species to migrate to cooler regions or die out [32].

Table 1. The area and production of oilseed crops during 2014–15 and 2015–16.

Crops	Year 2014–15			Year 2015–16		
	Area	Production		Area	Production	
	(000 acre)	Seed (000 tonne)	Oil (000 tonne)	(000 acre)	Seed (000 tonne)	Oil (000 tonne)
Rapeseed/Mustard	533	210	67	539	202	65
Cottonseed	7579	3450	414	7685	2966	356
Sunflower	349	182	69	214	92	35
Canola	37	17	6	36	16	6
Total	8498	3859	556	8474	3276	462

Source: Pakistan Bureau of Statistics [62].

4. Future climate and its effect on agriculture

Pakistan's economy relies heavily on agriculture and this sector contributes 24% to GDP and 70% to foreign exchange. Pakistan is the 8th most vulnerable country in response to the climatic changes, either directly or indirectly through impacts on its agriculture sector. Global warming increases the average earth temperature and changes the rainfall patterns. As per historical trends rainfall amount has reduced while intensity has increased. Devastating droughts and floods are projected with high frequencies in the country [33].

In long run, climate change could affect the quality and quantity of crops in terms of growth rates, photosynthesis and transpiration. Due to an increase in the average mean temperature, the duration of oil seed crop season can reduce subsequently leading to reduction in yield. An atmosphere with a high CO_2 concentration would result in a higher photosynthesis rate. In addition, rate of transpiration can reduce up to 30% in some crop plants [34]. Due to continued emission, greenhouse gasses will cause further warming and long run changes in all attributes of the climate system, increasing pervasive and irreversible impacts for people and ecosystems (Figure 1). The intergovernmental panel on climate change (IPCC) has predicted that the atmospheric concentration of CO_2 may increase up to 660 and 790 ppm in 2060 and 2090 respectively [6,20].

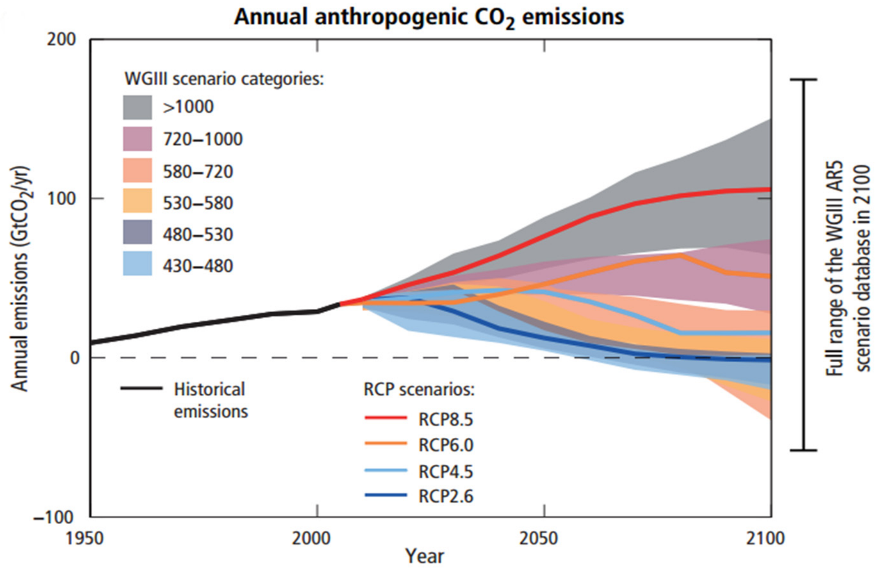

Figure 1. Emission of carbon dioxide alone in the representative concentration pathways (RCPs) and associated scenario categories used in WGIII (colored areas shows 5 to 95% range). The WGIII scenario categories summarize the wide range of emission scenarios defined on the basis of CO_2 concentrations. Level in ppm in 2100. Source: IPCC AR5 [63].

When concentration of CO_2 in the atmosphere increases, it results in higher net photosynthetic rates. The higher concentration of CO_2 also decreases the transpiration rates and this reduction could be 30% in some plant species [34]. Growth and yield of C3 plants can be affected by rising atmospheric CO_2, mainly through an increase in the rate of carbon assimilation and photosynthesis [35]. More specifically, the quality of sunflower seed oil can be affected by high concentrations of CO_2 [36].

Pakistan's agriculture is more dependent on monsoon rainfall; an increase in global temperature will change the patterns and distribution of precipitation. Any change in monsoon onset and withdrawal drastically affects agriculture. The real risk of climate change depends on how rapidly it takes place. Over the past 130 years mean global temperatures have risen 0.6–1.2 °C. Further evidence suggests that future increase in mean global temperature may occur at a rate of 0.4 °C each decade. Temperatures are projected to rise up to 5–6 °C by the end of the century (Figure 2). Continuous high temperatures can decrease the grain weight and oil yield in sunflower [37].

Global mean sea level is projected to rise by 0.2–0.6 m by the end of the century (Figure 3). A continuous rise in temperature has been causing expansion of ocean water. Sea-atmosphere interaction brings changes in physical processes resulting in sea level rising [38]. With a rise in temperature, large volumes of water have entered the oceans by the recession of glaciers [39].

4.1. Effects of environmental parameters on pollinator activity

Climate change is hazardous for pollination services [7,9,40]. A decay in the population of pollinators is a risk to food and crop production. Ultimately, it is a risk to the economy of farmers who rely on the mutualistic association among pollinators and plants. Risks to plant-pollinator relationships are therefore a direct threat to the human societies and thus is an important point to be taken into consideration. Bees are recognized as the most important pollinators throughout the world. These are ectothermic i.e. they need an elevated body temperature for flying. Biotic stress accompanied with climate change has caused a decline in the population of pollinators and has lead researchers to look for alternative pollinators [41]. Snow cover and drought conditions may decrease the flower numbers and nectar production, which ultimately limit pollinators foraging activity [42].

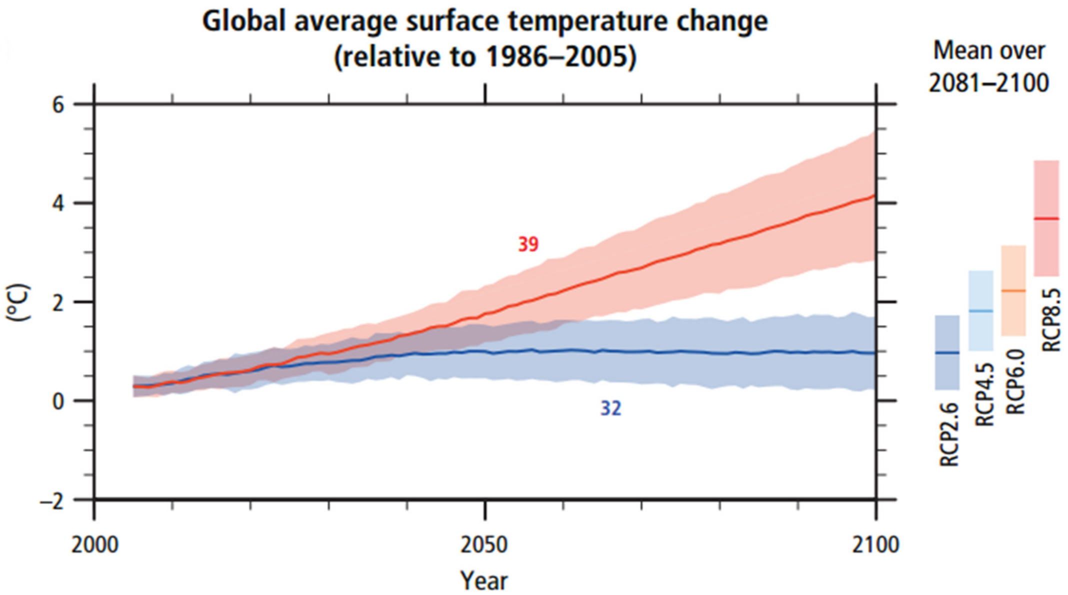

Figure 2. Future global mean surface temperature is estimated by multi-model simulations. All changes are relative to 1985–2005. Time series of projections and a measure of uncertainty (shading) are shown for scenario RCP2.6 (Blue) and RCP8.5 (red). Source IPCC AR5 [63].

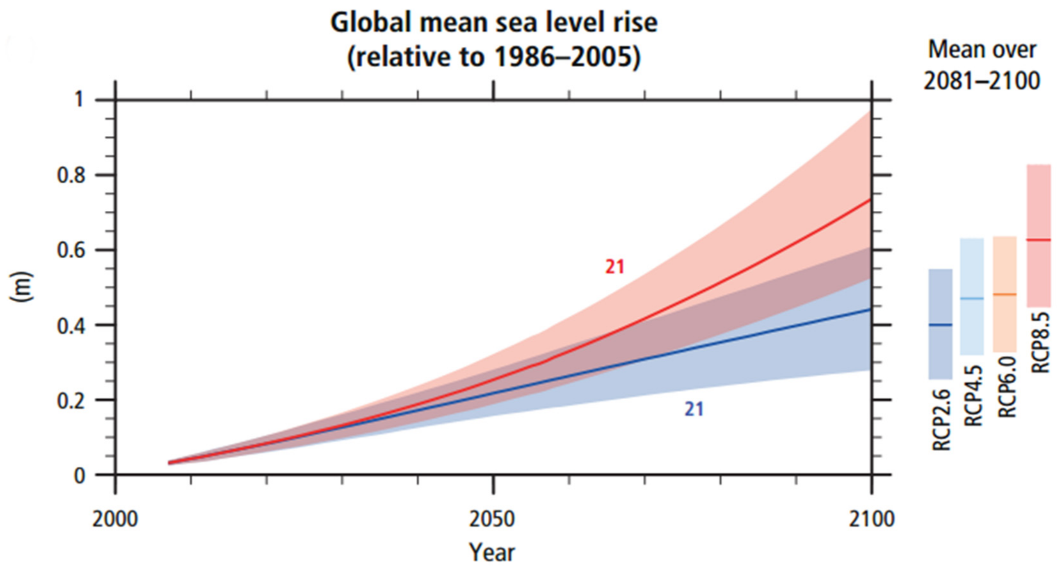

Figure 3. Global mean sea level rises substantially during the 21st century. Source IPCC AR5 [63].

4.2. Effect of winds and humidity

The emergent pollen release from several oilseed varieties is activated by moderately gusty winds. Similarly, spores from these varieties are originated by wind induced tremors of the leaves or by the kinetic energy of impacting raindrops. On the surface, a wind gust has the potential to pick up little debris particles, sedimented pollen and microorganisms such as bacteria and mites from the surface or host organisms. The National Center for Environmental Prediction (NCEP) Reanalysis wind vectors display inconsistent wind speed and direction over Pakistan that has made pollination ineffective in its environment. Dominating vertical wind velocity patterns suggests cold advection downdrafts as depicted by the NCEP Reanalysis over the Pakistan oilseed growing region (Figure 4). It suggests that wind eddies have not been plentiful enough to keep such minute biotic and abiotic objects aloft over the years.

Bees comb when temperatures are 13 °C or higher; they do not comb in rainy spells or in wind stronger than 5 m/s. Cloudiness also trims flight action, particularly near threshold temperatures. A honey bee commonly flies at a speed of 8 and 6.7 m/s when alone and carrying a load (e.g. pollen, nectar, or water) respectively. In fact, they are unable to carry a load more than a 6.7 m/s up-wind. In Figure 4, it can be seen that trends of horizontal wind speeds over Northern and Southern peripherals of Pakistan have trends converging to a threshold of 5 m/s with non-trivial slopes of up to 3 m/s over the region. Moreover, it is seen that the trend of vertical wind velocity is downdraft in the Northern half and updraft in the Southern half of the country. The slopes, however, display opposite behavior with updraft in the Northern half and downdraft in the Southern half, which in turn cause unsteady flows. Our grasp of how variable wind in natural surroundings affects flying insects is defined and definite. Bumble bees are "all-weather" combing insects and thus more often experience variable aerial conditions, ranging from fully mixed, turbulent flow to unsteady, structured vortices. The unsteady flow conditions curtails the upstream flight speed of bees, suggesting an increased expense of flight in unsteady flow, with potential implications for foraging patterns and colony energetics in natural, variable wind environments [43]. As wind speed increases, the routine of combing bees recess in a linear relationship and foraging behavior changes. A heavily-laden bee may not make the effort to fly against the wind in an attempt to return to its hive, rather it will enter the closest hive nearby. A strong prevailing wind may force foraging bees down to the end of a row of hives in an apiary or to downwind apiaries in a field or orchard setting [44-46].

The universal idea of updraft of a volumetric body in the atmosphere is described by Stoke's law of sedimentation, where the terminal falling velocity V_t of an object is

$$V_t = \sqrt{\frac{2mg}{c_w \rho A}} \qquad (1)$$

with m the mass (kg m^{-3}), g the gravitational acceleration (≈ 9.81 m s^{-2}), c_w the friction coefficient (≈ 1 for circular bodies, < 1 for aerodynamically formed bodies), ρ the density of the air (≈ 1.2 kg m^{-3} at sea level), and A the projected surface of the body (m^2). In fact, wind has virtually the same impact as the water flow in rivers: under strong turbulence and horizontal wind speeds, insect pollinators may seek shelter where they are not picked up by the motion of air. However, once they forfeit sticky contact, their body size and weight are too small to grasp ground again, and they become suspended in the air until they happen to end up in a calmer area where their settling velocity is greater than the wind motion, which allows them to reach the ground surface again. Bodies with dimensions smaller than ≈

10 µm are generally too small to return to the surface in the turbulent atmosphere. Therefore, for such small bodies, impaction becomes the most relevant process (when they physically hit the surface of a tree or another plant). The adhesive stigma of a flower's pistil further assists in capturing pollen even when the impaction is weak.

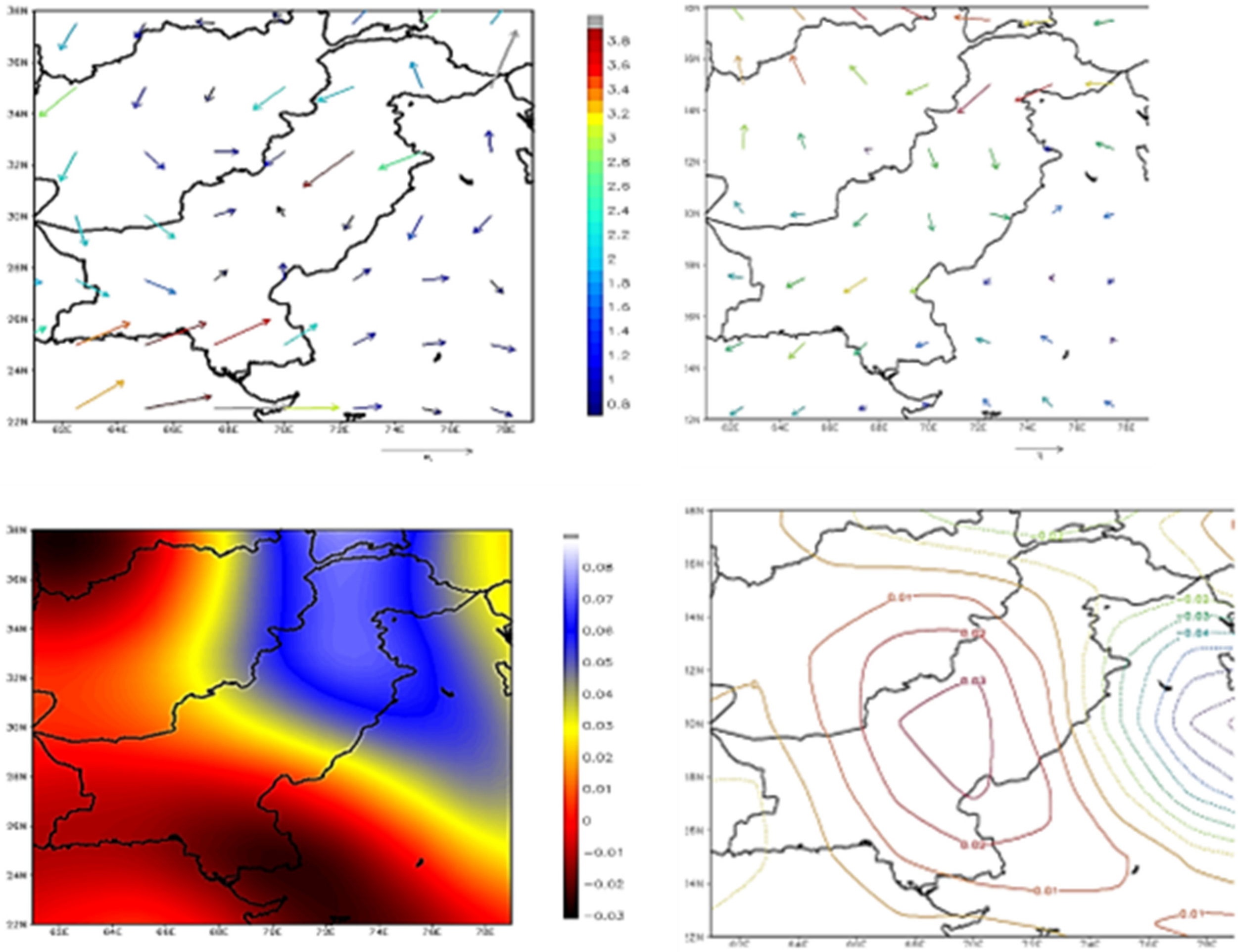

Figure 4. Horizontal wind vectors (m/s) magnitude trends (top left) and slopes (top right), vertical wind velocity (Pa/s) trends (bottom left) and slopes (bottom right) as depicted by NCEP Reanalysis datasets. Horizontal winds trends and slope are taken at surface level with time period of 1948–2016, whilst vertical wind velocities are taken at surface level with time period of 1979–2016.

Wind pollination is regarded as inefficient compared with insect pollination, yet the two are correlated. As per current magnitudes of wind speeds, small insects may need to adapt accordingly. Lab tests carried out in a wind tunnel signals that weak winds (> 0.2 ms^{-1}) do affect the flight and landing behaviors of the pollinators. The essence of the tests indicates that as wind speed increases, these small pollinators increasingly forfeit control over their flight trajectory and may no longer land over the desired target. Stoke's law explains the scattering of small seeds which possess hairs or parachute type annexes. This is best described by the Stoke's settling velocity (Equation 1) which explains that the wind scatters small seeds owing to their long dwelling time in the atmosphere (the dwelling time is inversely proportional to the terminal fall velocity). On the contrary, owing to more weight, large seeds do not travel greater distances with the wind. The major mode of their transfer is the dispersal by insects.

Wind pollination has meager chances to succeed in a tropical wet environment. It is a passive process, and requires environmental conditions to be favourable for seed and pollen dispersal. Outstanding diversity in wind attributes has induced uncertainty for a pollen grain to land on a conspecific stigma. Wind borne pollen plays a minute role in lasting pollination. Mostly pollen travels less than 10 m that renders an inverse relation of pollen source to distance travelled over that region [47,48]. Canola pollen dispersal range is variable from a few meters to 360 m and in some extreme cases, evidence of wind transfer of up to 1500 m is also available [47]. High humidity acts to reduce the amounts of pollen in the air, especially over the Northern half of the country (Figure 5). The high humidity trend over the Northern half reaches up to 85%, which tends to produce a downturn in the daily activity of honey bees. Moreover, higher humidity, heavy precipitation, stronger wind and lower daily temperature have a negative impact on the inflorescence of oilseeds [49]. In Pakistan, movement of canola pollen is restricted due to turbulent weather conditions. Airborne pollen dispersal distance varies with topography and environmental conditions. Moreover, pollen movement depends upon wind speed, wind direction and the surrounding vegetation [48,50]. Pollen transfer for long distance occurs when pollen grains are caught up by upward air movements and move above the height of vegetation.

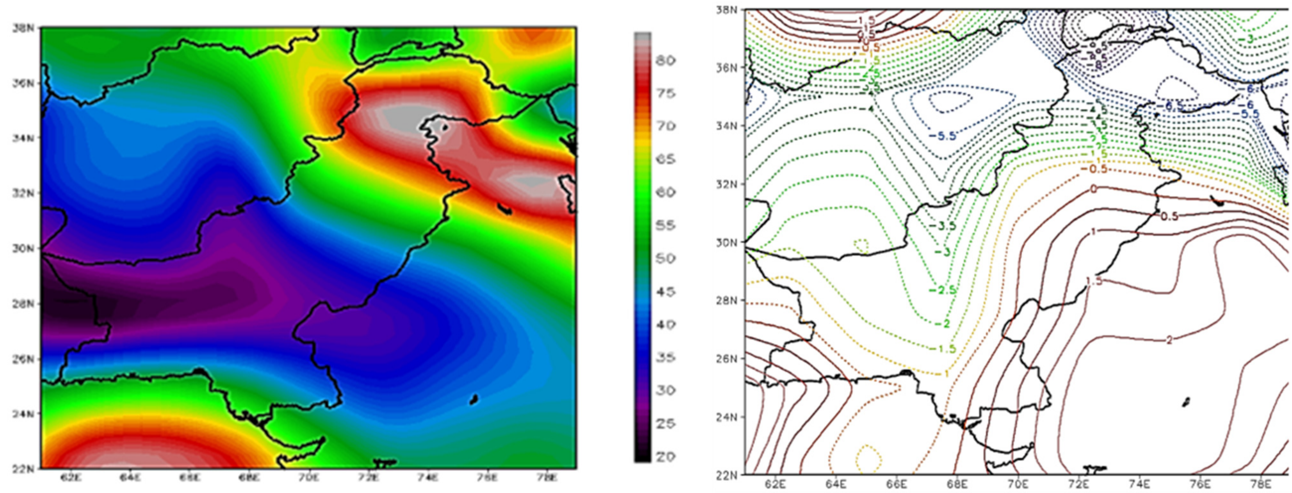

Figure 5. Spatial distributions of long term historical (1948–2016) trends (left) and slopes (right) of relative humidity (%) over the surface; depicted by NCEP Reanalysis datasets.

4.3. Effect of temperature

Hegland et al. [40] argued that temperature variation brought changes in the plant-pollinator relations. Plant pollinators and flowering activity seem to be affected strongly by temperature (Figure 6). A significant increase of up to 0.7 °C over the last 68 years is held responsible for current disrupted pollination activities in the Punjab region of Pakistan (Figure 7). Plants and insects might respond differently to temperature changes, creating spatial (distributional) and temporal (phenological) mismatches. Mismatches could affect the plant through reduced visits of insects and the subsequent reduced pollen depositions. The pollinators may also suffer from decreased food availability.

The Fourth Assessment Report (AR4) presented by the Intergovernmental Panel on Climate Change (IPCC) has documented several observed changes about global climate. Most notably, the IPCC has recorded an increase in global temperatures, a decrease in snow and ice cover, and a shift in the frequency and intensity of precipitation [6]. The most credible, with respect to plant-pollinator interactions, effect of climate change is an increase in temperature. The fact that 11 years out of the 12-year period from 1995 to 2006, rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850). IPCC [6] announced much uncertainty in the recent warming trends, which is forcibly affecting terrestrial ecosystems. This includes changes such as earlier timing of spring events and poleward and upward shifts in distributional ranges of plant and animal species [6,51]. Projections from the IPCC signify that average global surface temperatures will increase by 1.1 °C (moderate emission scenario) and 6.4 °C (high emission scenario) during the 21st century. This trend will be more pronounced in area of higher latitudes [6]. The biological effects of rising temperatures are contingent on the physiological sensitivity of organisms to temperature change. Deutsch et al. [32] reported that an expected future temperature increase in the tropics, though relatively small in magnitude, is likely to have more deleterious consequences on crop production as compared against the changes at higher latitudes (Figures 1 and 2). The possible reason for this is that tropical insects are relatively more sensitive to temperature changes. They can survive in a narrow range of temperature and their ambient temperatures are already much closer to the optimal temperature. Warming may genuinely embellish the functioning of insects living at these latitudes. It is for that reason it is presumed that tropical agro-ecosystems may suffer from greater population decline and annihilation of native pollinators than agro-ecosystems at higher latitudes. On the basis of patterns in warming tolerance, climate change is projected to be the most detrimental for insects in tropical zones of Pakistan with a mean temperature trend of up to 30 °C along the lower latitudes (Figure 7).

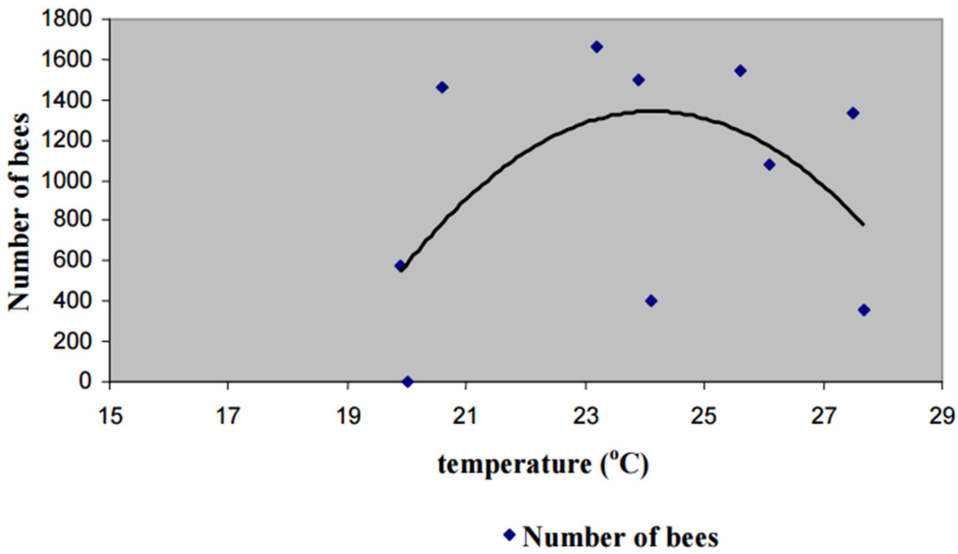

Figure 6. Influence of air temperature on honey bees visit of sunflower inflorescences during flowering time. Copied from Puškadija et al. [49].

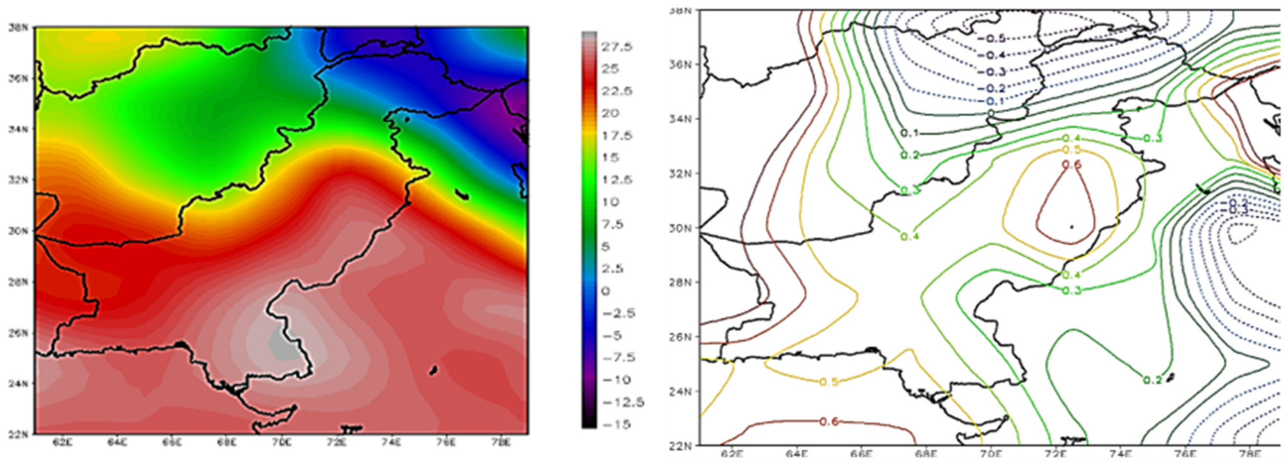

Figure 7. Spatial distributions of long term historical (1948–2016) trends (left) and slopes (right) of mean air temperature (°C) over the surface; depicted by NCEP Reanalysis datasets. Rate of change of mean air temperature is highest in Punjab region with up to 0.7 °C rise seen over the recent historical period.

4.4. Effect of precipitation

Climate change signatures seen over the historical period have altered current rainfall patterns with some zones experiencing reduced rainfall, leading to additional widespread drought phases across Pakistan (Figure 8). High precipitation may restrict pollinators' foraging exercises. Ideal foraging environment for pollinators are sunny days with low wind speed and moderate temperature. Climate change may likely reshape the current precipitation patterns. As seen in Figure 8, some areas over the Southern half of the country encounter decreased rainfall (less than 0.5 mm/day), causing more pervasive drought periods. The water stress thus caused may curtail the number of flowers and the subsequent nectar production. Snow cover might also be diminished due to melting at elevated temperatures. Undoubtedly, bumblebees have tried to reciprocate more to snow cover than to temperature [42]. In each occurrence, the most appropriate measure of precipitation must be determined.

Extreme temperatures and drought are short-term issues that will likely affect crops, particularly during anthesis [52]. The trend and slope analysis in Figure 8 clearly reveals a negative rate of change in monthly mean precipitation rate as seen in Punjab and KPK regions with a decrease of up to 1.6 mm/day. This will create moisture stress for agricultural crop production. In fact, flowers with fewer attractants are less attractive to pollinators [53-56] and will experience cutback in pollination levels, resulting in curbed seed quality and quantity [57,58]. Crop species withstanding drought stress may also produce lighter seed weight and seed count, resulting in reduced yields [59]. This water stress could result in less flowers with decreased nectar production (Figure 9). Yield decline under drought conditions may also emerge from a reduction in pollen survival along with an increase in seed abortion rates [60,61].

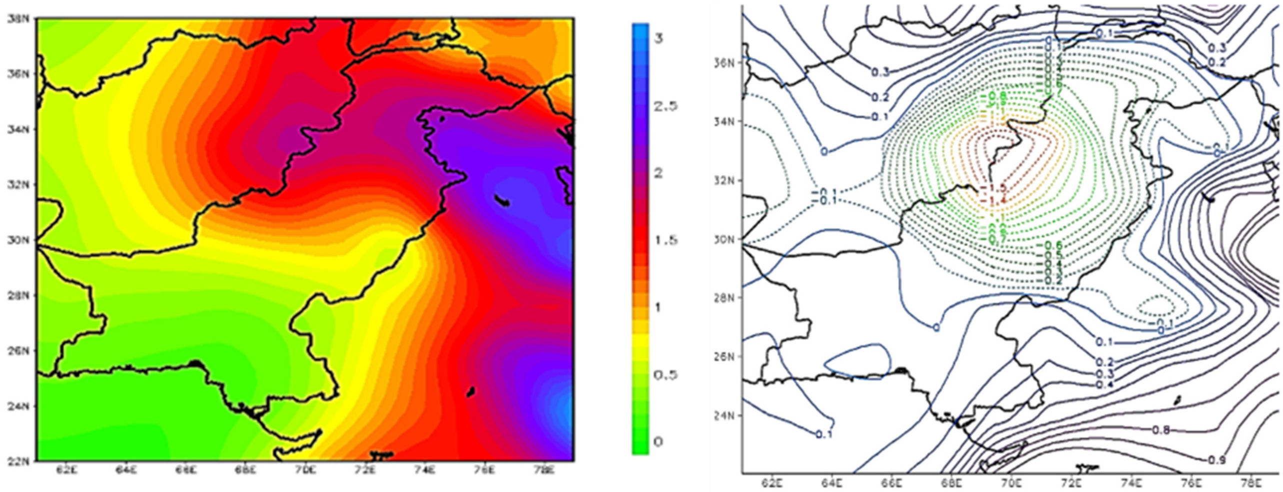

Figure 8. Spatial distributions of long term historical (1979–2016) trends (left) and slopes (right) of monthly mean precipitation rate (mm/day) over the surface; depicted by NCEP Reanalysis datasets. A negative rate of change in monthly mean precipitation is seen in Punjab and KPK regions with up to a 1.6 mm/day decrease that brought water stress conditions over the oil seed region.

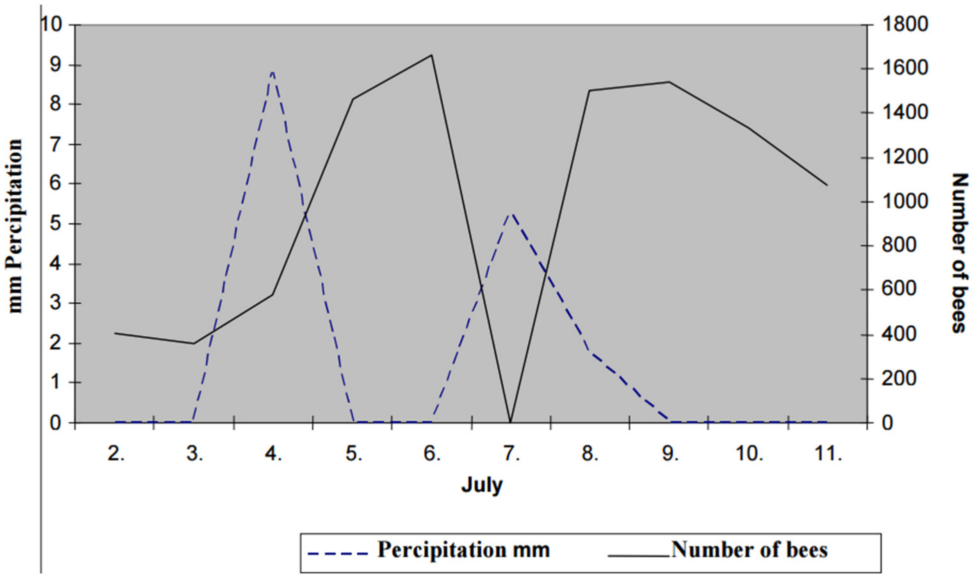

Figure 9. The precipitation influence of honey bees visit on sunflower hybrids. Copied from Puškadija et al. [49].

5. Policy recommendations

The project Status and Trends of European Pollinators (STEP) (http://www.step-project.net/) records the nature and volume of decline in the population of pollinators, observes practical trends related to specific hazards, develops a red list of crucial European pollinator groups (especially bees), and lays the basis for future pollinator monitoring programs. STEP also examines the relative significance of potential drivers of such changes, which includes climate change, habitat loss and fragmentation, agrichemicals, pathogens, alien species, mild pollutants and their interactions. STEP measures the ecological and monetary impacts on declining pollinator services and floral assets together with consequences on wild plant populations, crop production and human nutrition. It also evaluates current and potential mitigation alternatives, offering novel checks of their effectiveness throughout Europe. The work builds upon current datasets and models, complemented by means of spatially-replicated campaigns of field studies to fill gaps in contemporary understanding. STEP integrates the findings into a policy-applicable framework, developing evidence-based decision support tools. It additionally sets up communication links to an extensive variety of stakeholders throughout Europe and beyond, together with policy makers, beekeepers, farmers, academics and the general public. Altogether, the research come policy program enhances our knowledge of the nature, causes, outcomes and potential mitigation of declines in pollinator services at local, continental and international scales.

Inspired by the STEP mission, a robust policy approach is required that takes into account the most important strides towards filling contemporary knowledge gaps concerning pollinators. A proposed work plan may record current traits in pollinators and insect-pollinated flora, investigate the function of various drivers in inflicting such tendencies, examine the ecological and monetary impacts of these modifications and of potential mitigation actions that can be taken, and disseminate findings to an extensive range of stakeholders. The work plan may also involve an inclusive approach by considering the widest range of pollinator taxa, including both controlled pollinators (honeybees and a few bumblebee and solitary bee species) and wild pollinators (bumblebees, solitary bees, hoverflies and butterflies). All these groups make contributions to unique aspects of pollination services for Pakistani crops and the wild flora.

In general, it is advised to evaluate the contemporary status and traits of pollinators in Pakistan, quantify the relative significance of various drivers and effects of change, perceive applicable mitigation techniques and policy units, and disseminate this knowledge to an extensive range of stakeholders. This may be supported via sixteen unique objectives which can encompass the work plan of future pollinator protection program in Pakistan.

1. Document the status and traits of pollinator (controlled honeybees, wild bees and hoverflies) and animal-pollinated plant populations.
2. Determine and examine the multiple pressures that are driving changes in pollinators and animal-pollinated flowers at scales ranging from single fields to landscapes to the whole of the country.
3. Determine the effect of changes in pollinator populations and groups on wild plant life and vegetation and changes in floral resources on pollinators.
4. Evaluate and synthesize techniques to mitigate the impacts of adjustments in pollinators and animal-pollinated plant life.
5. Examine how a couple of drivers have an effect on pollinators and animal-pollinated plant life at local scales using centered empirical checks and observations.
6. Analyze and enhance the interface between the scientific expertise based on pollinator change evaluation and policy instruments to lessen pollinator / pollination losses and mitigate its effects.
7. Increase communication and academic links with an extensive variety of stakeholders and the general public on the significance of latest shifts in pollinators, the main drivers and impacts of pollinator shifts and mitigation strategies via dissemination and training.
8. A comprehensive and coordinated policy is needed urgently to mitigate the negative effects of climatic shifts. It is important to harness the potential of both human and natural resources

efficiently and efficaciously. Development of short-duration oil seed crop varieties is recommended since these mature before the onset of peak-heat phase.

9. Government needs to formulate and implement clean technology policies to stop the increased harmful carbon emissions that would otherwise result in climatic disaster.
10. Government should formulate a committee to analyze the situations objectively and recommended short, mid and long term strategies for dealing with the deleterious effects of climate change.
11. Government needs to provide comprehensive information to the farmers on potential impacts of altered climate change circumstances on crop pollination.
12. Researcher must focus on increasing the pollinators' population, which is effected by increase in environmental factors.
13. Beekeepers need to seek knowledge of the projected climate trends while wintering honey bee colonies, both outdoors and indoors. It will assist in optimizing winter survival rates by managing colonies to ensure proper health of the pollinators.
14. Engage climate change vulnerability assessment recommendations for selected wild pollinator species.
15. Save and restore wetlands, grasslands and woodlands.
16. Expand green spaces that offer habitat for pollinators.

6. Conclusion

Although accurate impacts of climate change are difficult to project, pollinator decay can be augmented by altering the balance between bees and their environment, counting for an increase of their liability and risk of diseases. Climate change incites earlier spring thaws that end in many plants blooming earlier than normal in Pakistan. As a result, pollinator species could experience a population drop if plants bloom at times when pollinators are inactive. Pollinators also demand uninterrupted connection and access to food resources. Shifts in crucial seasonal changes such as flowering time and emanation of insects, could lead to gaps in the succession of flowers, causing unfilled appetites for longer-lived colonies of pollinators. Radius of influence for pollinators may also shift as temperature increases. Bees that live in tropical environments are anticipated to extend their ranges, whereas bees that live in narrow-ranged temperate climates may probably experience range shrinkage and are at risk of population lapse. In addition to the gradual increase in temperature over the last century, climate shifts have caused more frequent extreme weather events like storms, floods, heat waves and droughts in Pakistan. Pollinators have already been stressed by climate change impacts, and extreme weather events can have further severe impacts on these pollinators by causing high overwintering losses. Less roving pollinators, such as small beetles and ground nesting bees, may be the most severely affected by events such as flooding and gusts. Extreme weather can not only disrupt individual insect livelihood but can also negatively impact entire colonies and the native populations.

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Conflict of Interest

None declared.

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