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Review

PARAMOUNT EFFECTS OF CLIMATE VARIABILITY ON BIRD SPECIES

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Abstract

Birds are excellent indicator of alteration in the environment but global conservation programs on bird species diversity and richness are usually threatened by climate change. Climate change is the world's indisputable environmental problem, currently affecting conservation programs in advance and developing countries concurrently. This paper aims to give detail summary, using hypothetical and investigated evidence documented in literature to identify and discuss the effects of climate variability on bird species and its implication on conservation of birds. Climate change is a function of activities of the populace resulting to alteration of the ecosystem. Some of the paramount effects of climate change on birds are; alteration in the duration of breeding seasons, alteration in migratory locations, alteration in niche structure, reduction in survival and breeding venture, shift in timing and duration of breeding, modification of long-term migration and breeding performance, modification of avian morphology, homelessness and scattering of migratory birds, forest-fire, pest and diseases outbreak. Birds may adjust to climate variability by escaping when the atmospheric temperature is till trivial, they may adapt to the local environment or die. The special effects of climate change on prospective wild population of bird species are; increase in competition on foraging sites because the choice made one bird is dependent on choice made by others in a specific habitat. Bird's survival is dependent on its ability to forage very fast and dominate. Local carrying capacity of birds may be exceeded in isolated areas. Effects of climate variability on birds are complicated and species dependent. Understanding how individual species will respond to this global change in the ecosystem will enable avian managers to propose a better conservation measures. Continuous monitoring of birds in changing environmental conditions is necessary in order to understand how individual species will respond to diverse environmental variability.

Keywords: *Climate change; birds; ecosystem, migration; breeding; adaptation*

INTRODUCTION

Climate can be defined as a combination of weather proceedings exceeding a prolonged age of time. Weather has a huge effect on avian species, this is a well-known problem (Crick, 2004), being both dissimilar and essential. Climate change is a product of human activities resulting from alteration of the ecosystem. In order to measure the impact of climate change on bird species long term planning is required. However, birds are excellent indicator of alteration in the environment (Jirinec *et al*., 2021). Climate change can be defined as considerable alterations in global environmental parameters such as temperature, precipitation, wind patterns and other average weather conditions of a place that occur and measured over several decades or more. This is also known as a change in weather conditions over several generations and decades. However, an average alterations of weather conditions for either a long or short time, might influences some biotic process such as radiation, tectonic plates, volcanic eruptions and naturals disasters (Dimitrov, 2019).

Increasing levels of carbon dioxide and greenhouse gases (GHG) concentration in the atmosphere is responsible for rising sea level coupled with ocean acidification and change in the ecosystem. Apart from that, human activities such as construction of permanent structures, bush burning and

deforestation are equally responsible for increased GHG and example of greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs). Greenhouse gases (GHG) are answerable to global warming, which can be best described as product of industrial, agricultural, and transportation activities carried out over a long age of time. The main contributor to overall GHG emissions is CO_2 (Sulaiman and Abdul-Rahim, 2018) and more than 60% of these gases are made up of CO_2 (Kaygusuz, 2009). Incidence of climate change, with pronounce evidence in increasing temperature, unpredictable rainfall, increased rainfall in coastal areas, evapotranspiration, persistence increases in sea level and flooding, drought, desertification, land degradation, bush fires, thunderstorms, lightning, drying up of rivers, lakes and nonstop loss of forest cover have been documented globally. The aforementioned factors are currently affecting fresh water ecosystems, resulting to loss of biodiversity (Elisha *et al*., 2017). Global conservation programs on bird species diversity and richness are usually threatened by climate change (Alam *et al*., 2015. In recent time, there has been an increase in policy formulation towards addressing problems related to climate change by the internal communities.

Climate change is the world's indisputable environmental problem, currently affecting conservation programs in advance and developing countries concurrently. The substantiation on climate change is so evident and cannot be underestimated, because it is not easy to predict the way some regions and countries will be affected. In addition, it is also not easy to predict how the associated wildlife species will be affected by the phenomena. Excessive runoffs in developing countries in recent time have increased, due to increased intensity and prolong rainfall resulting to flooding (Enete, 2014; Haider, 2019). Variation in rainfall pattern is anticipated to continue to increase with corresponding rise in precipitation in the southern areas, resulting to rising sea level characterized by aggravated flooding and submersion of land in the coastal areas (Ebele and Emodi, 2016). Therefore, this paper aims to give detail summary, using hypothetical and investigated evidence documented in literature to identify and discuss the effects of climate variability on bird species and its implication on conservation of bird species.

Climate change is a function of activities of the populace resulting to alteration of the ecosystem. Some of the paramount effects of climate change on birds are;

i. alteration in duration of breeding seasons
ii. alteration in migratory locations
iii. alteration in niche structure
iv. reduction in survival and breeding venture
v. shifts in timing and duration of breeding
vi. modification of long-term migration and breeding performance
vii. modification of avian morphology
viii. modification of bird's populations
ix. homelessness and scattering of migratory birds
x. forest-fire, pest and diseases outburst.

Alteration in Duration of Breeding Seasons

Ecological temperature can be defined as the hotness and coldness of the environment. However, temperature and climate change are capable of disturbing reproductive performance in diverse bird species and sites. There is a correlation between laying date and temperature, this relationship may erupt first and foremost as a result of the impact of temperature on active stress on the females that stimulates their timing of egg production. Secondly, the advancement of the gonads could be stimulated by temperature, thereby affecting the scheduling of laying indirectly. Precipitation may produce a related consequence in the growth of spotted ant-bird, because the testes and follicles during the arid period of the year is slower in the Panama (Dunn, 2004).

Garant *et al*. (2008) reported the growing evidence from continuous research which shows that, birds have a relationship with their date of laying eggs and increase average temperatures. Then again, the period of laying has great impacts on total breeding performance, because tough genes are responsible for the development of individual bird species coupled with their physical and physiological appearance (Garant *et al*., 2008). In addition to time of breeding and clutch size, which are key indicators of overall reproductive success in birds generally, moderate temperature also contributes to improved reproductive success. Gradually, different bird species are scheduling their egg-laying in reaction to climate modification. This was also reported by Halupka and Halupka, (2017) from a metal-analysis of 65 long-standing investigations of 54 bird species from the Northern Hemisphere which demonstrated that in the previous 45 years, the mean populations of bird species have stretched out the season by 1.4 days in each ten years which does not depend on average egg laying dates, whereas in a single-brooded species, it has been abridged by 2 days.

There was a relationship between elongated season and warming in multi-brooded species, but such relationship does not exist in single-brooders. The correlation between elongated season and warming in multi-brooded species is a

function of advanced ecological compliance in bird species that are multi-brooded, whereas in single brooders there could be some challenges with harmonizing their ability to reproduce within the period when foraging items are in topmost supply. Elongated egg laying period were observed in sedentary birds and other bird species that practices short distance migration, compared to bird species that practices long- distance migration. This could be due to their inability to understand the new conditions in their breeding sites. From all indication, reproduction in multi-brooded or sedentary species will continue to increase with corresponding increase in warming whereas the reverse effect might arise in bird species that are migratory or single-brooded (Halupka and Halupka, 2017). By modifying their breeding period, variation in climate conditions might likely adjust a number of other factors of reproductive processes in bird species such as the number of clutches and size of clutches, incubation behaviour and recruitment (Egwumah and Iboyi, 2017).

Alteration in Migratory Locations

From a mathematical model forecasted by Clairbaux *et al.* (2019) on climate change, it was estimated that by 2050 the sea ice in Arctic Ocean will disappear in each summer. If this barricade is eliminated amid the Atlantic and the Pacific, series of biological processes will be altered with migration of bird species inclusive, for examples 29 species of seabird that are notorious for breeding in arctic region, which recently journey to the North Atlantic may change to transarctic with the main intention of journeying near the North Pacific. From their prediction, about 24 species of seabird bird that breeds in arctic region might be force to modify their migratory approach into an excellent resident bird living in arctic region throughout the year.

Consequently, melting of snow prior to spring, advanced temperatures in diverse seasons of the year coupled with rises in evapotranspiration is currently responsible for extension of the duration in which forestlands and other forms of wildlife home range becomes highly inflammable (Heyck-Williams, 2019). Similarly, the vulnerability of forestlands to forest-fire may escalates due to advanced temperatures and severe arid conditions. The aforementioned factors could generate strain in tree species which result to death of the plant that bird species utilized for perching, foraging, breeding sites, breeding materials, shelter and escape medium from predators. Modification in breeding sites may alter reproductive performance due shortage of food, breeding sites and materials.

Alteration in Niche structure

According to Ecological niche (2019), a niche can be defined as a biotic structure and any part of the ecosystem that carried out a specific function made up of one or several species populations. Instance a primary niche is made up of the producer, consumer and decomposer. It is also known as the home range were bird species inhabit. Apart from that, the function of bird species in the environment can also be used to define niche. Similarly, the interrelationship between bird species and non-living components of the environment affecting them can equally be used to define niche.

Wiens *et al.* (2009) utilized evidence on distributional shifts in flora composition to predict fine scale prospective dispersals of 60 terrestrial bird species in California, through the adoption of species distribution models with respect to recent biological niche limitations. Decline in terrestrial birds by the year 2070 was anticipated coupled with holistic variation in species richness a cross the study areas, whereas the hotspot will be most affected with huge loss of vulnerable species. Modification of the various components of the niche structure such as the producer, consumer and decomposer might affect the proper functioning of the ecosystems, bird species home range coupled with the interrelationship between bird species and non-living components of the environment. Therefore, prospective conservation program should put future conditions into protection and supervisory practices for effective avian conservation with respect to global increase in climate variability.

Reduction in Survival and Breeding Venture

Skagen and Adams, (2012) reported that comparatively strong day-to-day precipitation proceedings in a short term, may negatively affect day-to-day survival of nests. However, there was a positive correlation between nest survival and temperatures all through the breeding time of the year. Reduction in precipitation during summer might decrease the possibility of Lark Buntings sustaining an even breeding populations in the study sites, even with a regular rise in temperature of about 3^{o}C could improve degenerations of survival, projected alongside with arid conditions. Notably unpredictable climate in the great grasslands opt for some level of caution and deceitfulness instead of robust site loyalty, coupled with precise adjustment to native surroundings. The aforementioned characteristics might result to northward alterations in distribution, once the environmental circumstances such as climate and home range conditions are less satisfactory especially in Southern

areas where the vegetation is gradually drying up, if the great grasslands is critically examined. Modification in distribution of Lark Buntings might be inhibited through prospective alteration in various uses in which land are put into use for example farming or any vegetation structure that might bring about additional loss of grassland vegetation (Skagen and Adams, 2012).

Imlay *et al*. (2018) equally examine the effects of climate variation on breeding performance and phenology for the following bird species Bank swallow *Riparia riparia*, Barn swallow *Hirundo rustica*, Cliff swallow *Petrochelidon pyrrhonota*, and Tree swallow *Tachycineta bicolor* and they reported that clutch commencement dates move forward by 8–10 days for some selected bird species with Bank Swallows exclusive. In their breeding sites, fewer precipitation during winter for a specific year were connected with earlier breeding and alteration nestling survival in Barn and Tree Swallows whereas warmer winter environmental hotness were connected with earlier breeding and alteration in nestling survival in Tree Swallows. Winter temperature and precipitation did not affect breeding performance. From all indication, Bank Swallows has the least breeding performance and reduced population which could be a function of inability of the said species to adjust to climate modification. However, other avian species such as Barn swallow *Hirundo rustica*, Cliff swallow *Petrochelidon pyrrhonota*, and Tree swallow *Tachycineta bicolor* were not affected (Imlay *et al*., 2018).

Shift in Timing and Duration of Breeding

Hällforsa *et al*. (2020), utilized more than 820K nesting data and records of 73 avian species crosswise the boreal area to investigate modification in the commencement, termination, and length of breeding season for more than 40 years (1975 to 2017) and the reveal over-all earlier initiation of breeding with robust phylogenetic indication, without efficient difference over space. Within this period there was a shrink in breeding season of some species amounting to 31 percent in a minimum of single bioclimatic area. If the period as breeding progressing is compared with the commencement. In mixture of diverse migratory approach or number of broods, there was absence of statistical variation in phonological responses of bird species. Efficient variation in bird species responses was reveal, whereas resident bird and bird species that practices short-distance migration were entirely notorious for shrinkage in breeding season. Inclusive, variations in scheduling and length of breeding might possibly result to further broods coinciding in early breeding period, which is a dangerous period for avian reproductive accomplishment (Hällforsa *et al*., 2020). The study equally reveal significance of evaluating phonological alteration across species with respect to the complete season. This will enable researchers to bring into limelight changes in community-level dispersal in breeding of targeted avian species (Hällforsa *et al*., 2020).

Birds are very sensitive to environmental changes. Norman and Peach (2013), used 23 years' research statistics on capture, mark and recapture techniques to evaluate the survival proportions of bird species between yearly changes in enrolment. However, the survival of fully-grown birds correlated positively to precipitation in wintering ground in sub-Saharan Africa, but in their breeding sites, dissimilar correlation occurs between precipitations. They reiterated that, additional satisfactory conditions may stimulate a rise in avian population and survival rates of fully-grown birds in their sub-Sahara African wintering sites.

Doswald *et al*. (2009) used methods of climate response surfaces and generalized additive models (GAMs) to investigate computer-generated possible future and present-day ranges with the main aim of comparing the ranges to determine the relationship and degree of overlap with respect to location. From all indication, in numerous scenario impending future areas utilized basically, not for breeding were replicated in areas not close to current areas utilized for breeding by European Sylvia Warblers. This signifies the likelihood of developing a fresh migratory approaches and routes with respect to climate alteration. Migratory birds are more at risk and they are estimated to be the most hit by climate modification compare to bird species that practices short distance migration and resident birds. Migratory distance in trans-Saharan migrants is likely experience maximum prospective increase, whereas species that are restricted to range are anticipated to face key population declines due imperfect or absence of commonality amid present-day range and possible future ranges (Doswald *et al*., 2009).

Bird species equally need favourable conditions to stimulate increase in survival rates of adults, because survival rate is a function of the number of birds exploiting a specific habitat. As rainfall commences, it sends vital breeding signals to birds and they are forced to migrate to Africa. However, the variation in precipitation pattern coupled with the volume of rainfall and period of the year, may affect breeding venture (Boere *et al*., 2006). This could be attributed to climate change because with climate change, the volume of rain may be absence or erratic in some areas all year round. Thereby affecting the quantity and quality of feeding items available to bird species. Birds may not breed once there is a decline in quantity and quality of available feeding items (Egwumah and Iboyi, 2017).

Temperature may stimulate increase in feeding items such as insects and shortage of food may restrict the female from producing eggs, therefore feeding items and gonadal advancement may be connected. It is anticipated that Warmer temperature may result to assemblage of young ones, since laying earlier is usually connected with bigger clutch size and fledging of increase young ones. In great tits *Parus major* from current substantiation, reveals that discrepancy in the scheduling of egg-laying may occur as a result of warmer spring temperature which could be linked to accessibility of feeding items for nestling and females that my lay eggs earlier are faced with the challenges of fewer young ones surviving. Investigating the effects of climate changes in every part of avian reproduction such as laying date and clutch size becomes imperative. However, key impact on fitness is a function of clutch size and it determines maximum edge on sum of procreative success for every identified brood (Dunn, 2004).

Another major relationship between birds and climatic factors is rainfall. As rainfall increase, there is also an increase in population of birds because increased rainfall provides more food and improved microhabitat for birds to breeding. During rainy season the trees are luscious, resulting to production of more flowers and fruits especially between the months of August to October. This period coincided with the period when bird's populations demonstrated great correlation with precipitation (Egwumah *et al*., 2014). Birds are more spread in population during the rainy season, but during arid months of the year, they are restricted to rivers bathing, drinking and preening. The presence of water (Warburton and Perrin, 2006) also serves as one of the paramount factors influencing the distribution of birds, but infiltration of rainwater into the nests could be responsible for nest failure during the nesting period especially in cavity nesting birds (Piebeng *et al*., 2017) such as African grey parrots and lovebirds.

Apart from that, food and excellent microclimate are fundamental elements influencing distribution, and supporting their breeding performance. Due to variation in environmental temperature, more birds were sighted during chilling environmental conditions in daylight period compare to sunset (Warburton and Perrin, 2006). Well, production of sperm takes place at night in fully grown male birds due to lowest receding of body temperature, but hatching failure may occur during breeding season, if the microclimate temperature within the nest cavities is not suitable for birds. Bird species in most cases harness their breeding period to blend with when foraging items are readily available in large quantity in order to stimulate successful reproduction because breeding is highly delicate to ecological signals. As scheduling of breeding drifts in line with climate modification, it is not only the inception of breeding that will be affected, but also the expiration and how long breeding will last. Therefore, food, water and microclimate are essential for healthier home range improvement, to enable bird species breed maximally with little or absence of mortality.

Modification of Long-term Migration and Breeding Performance

Meller, (2016) used long-term observation statistics to test the effects of changeability in ecological temperature and additional parameters of interest in passerine bird's surrounding with respect to migratory behaviour and breeding performance. It was reported that, earlier commencement of breeding occurs in warm springs resulting to more time been spent in breeding sites, since the scheduling migration in autumn is unbroken (just newly develop offspring from cutting-edge broods might migrate late). Moderate population of young ones was reported at the end of warm spring's production, but homogenously greater, compared to the end of cold spring.

Yearly production and population size were not the same amid existing species. There was a relationship between yearly temperature, output and population size, prolong population drifts were not linked to variations in output. It simply means that, variation in survival within the non-breeding period might be responsible for energizing these tendencies. Mild winter temperatures stimulate greater fractions of waterbirds that practices incomplete migration to hibernate in Finland compared to cold winters. A rise in fraction of resident waterbirds will be observed with respect to climate warming due to absence of serious ice winters, but in land-birds such drifts was not detected within the period of investigation. The life-history traits of bird species could be reactive to changes in environmental temperatures coupled with variation between taxa and functional diversity. Therefore, it becomes imperative to examine various taxa to enable wildlife managers make all inclusive conclusions and project the impacts of nonstop changes in environmental parameters such as precipitation, temperature, solar radiation and relative humidity on avian species (Meller, 2016).

Modification of Avian Morphology

For more than four decades' morphometric data on bird species that are not migratory and understory assemblage were investigated in Amazon Forest. However, the aforementioned forest is current been hit by severe climate.

In all, 77 species demonstrated decrease mass right from early 1980s. There was also a concurrent rise in wing length resulting to reduction in the ratio of mass and wing in 69 percent of the species studied. However, changes in precipitation with respect to seasons gives a better clarification compare to temperature. Consequently, variation in climate conditions within a short period of time affects all parameters. Although, time drifts in wing and ratio of mass to wing were still very strong in as much as yearly seasonal conditions were regulated. From all indication, immense pressure to stimulate a rise in resources in changing environmental conditions could be responsible, because both seasonal and prolong morphological drifts were pointing accusing fingers at climate change with respect to its prevalent cost, even in the center of global biggest rainforest (Jirinec *et al*., 2021).

Bird species may be decreasing or increasing their body sizes to enable survive increasing climate variability. However, this modification of body size is a function of geographical locality and the form of climate related problems been faced. For example, in extremely hot and dry weather conditions birds were discovered to escalate their size, connected to ability of little avian species were able to cope with heat-waves (Koop, 2020).

Modification of Bird's populations

Reduction in population of bird species may result from climate alteration. Stephens *et al*. (2016) gave an account of bird species that were projected to gain from climate alteration or their connected effects, experiences some level of increment, whereas those projected to be affected negatively experienced some level of decline. Bowler *et al*. (2017) reported a reliable effect of temperature variation on indigenous abundance of land-dwelling species. In warm dependent wildlife species, there was in an increase in population, compared to cold dependent wildlife. In distinction, effects of temperature variation on marine wildlife species' abundance were inconstant, indicating that the effect of temperature alteration has become prevalent with respect to alteration in abundance of diverse land-dwelling communities. Therefore, in diverse ecological conditions and communities, climate alteration might be anticipated to modify wildlife population size.

Homelessness and Scattering of Migratory Birds

Clairbaux *et al*. (2019) adopted the principles of all migratory organisms are faced with challenges related to homelessness and scattering. They illustrate the effects of climate alteration on little auks and reported with the recent and near prospective sea ice environmental setup. Homelessness and scattering of seabirds into the North Pacific perhaps might occur. With homelessness, some bird species may migrate from North Atlantic breeding clusters and fly over Arctic Basin just to access the North Pacific. Nevertheless, they might not breed over there or even take a return flight back to the Atlantic, whereas in scattering, some bird species may relax and reproduce in North Pacific. Some bird species may want to have a minimum of one breeding trial in the aforementioned breeding site. This was the typical scenario for some little auk that were examined. In addition, in the course of migrating back in spring, bird species will have to utilize the exterior to escape compressed sea ice. Apart from that, the occurrence and the grade of prospective stopover ground could be a key obstacle. Stopover ground are basically design as foraging and relaxing ground for diverse polar wildlife species, specifically, for the duration of winter season. Similarly, bird species flying towards the contrasting edge of the Arctic, might result to mingling of genes among earlier secluded populations. In the course of this association, diseases including some parasite might be transmitted between bird species (Clairbaux *et al*., 2019).

Climate alteration is one of factors responsible for decline in population of avian species, in most case it could be as a result of shortage of feeding item. Wrong timing of season when there could be high availability of feeding items and maximum food demand may result from climate change, especially from advancements in breeding phenology coupled with total shortage of accessibility of feeding items. Floating bird species that depends on insects as source of food are currently facing sharp population regressions. This is possible due to drifts in scheduling, coupled with abundance of floating insects (Imlay *et al*., 2018).

Forest-fire, Pest and Disease Outbreak

Bird species are faced with more risk with intensification in climate change in diverse ways. Stopover ground are basically design as foraging and relaxing ground for diverse polar wildlife species, specifically, for the duration of winter season. Similarly, bird species flying towards the contrasting edge of the Arctic, might result to mingling of genes among earlier secluded populations. In the course of this association, diseases including some parasite might be transmitted between bird species (Clairbaux *et al*., 2019).

Melting of snow prior to spring, advanced temperatures in diverse seasons of the year such as rainy season and dry season (in Africa) or spring, summer, and fall (in United State of America), coupled with rises in evapotranspiration are currently responsible for extension of the duration in which forestlands and other forms of wildlife home range

becomes highly inflammable. Similarly, the vulnerability of forestlands to forest-fire may escalates due to advanced temperatures and severe arid conditions. The aforementioned factors could generate strain in tree species which result to death of the plant. Apart from that, outbursts of insect pests might be aggravated, resulting to a rise in vulnerability of forestlands to forest-fire. A typical of example of insect that could exposure forestland to forest-fire is bark beetles (Heyck-Williams, 2019). Seasons could exist in severe form based on climate proceedings for example wet season could be more wet and dry season could be more dry. In full wet season abundant vegetation growth is usually stimulated and at the end of the dry season, the vegetation dries up completely leaving behind large percentage of dry matter on the forest floor. These dry matters end up serving as fuel for forest-fire.

How does Bird Species Survive with Climate Variability?

In most cases bird species may adjust to climate variability by escaping when the atmospheric temperature is till trivial, they may adapt to the local environment or die. However, habitat tracking is one of the foremost and outstanding mechanism utilize by bird species to adapt to climate variability. In this approach avian species trails thermal coverage that is familiar to their body system, in the course of flying up in latitude or altitude (Blondel, *2019).* Apart from that, adjust to escalating temperature especially if the heat produced is not generated at a very fast rate or generated at a very high rate. This can be achieved through modification of genetic structure of the population. If the bird species cannot utilize any of the aforementioned mechanism to survive, probably extinction is certain. Bird species utilizing high mountainous areas or tundra are highly susceptible to extinction due to inhibition of flight by geographical restrictions. Long-distance migrants are potential victim of this novel challenges because the journey through diverse habitats.

As part of survival strategies to withstand climate change, bird species may be decreasing or increasing their body sizes to enable survive increasing climate variability. However, this modification of body size is a function of geographical locality and the form of climate related problems been faced (Koop, 2020).

Effects of Long-term Climate Variability on Bird Species

The special effects of long-term climate change on wild population of bird species are;

i. increase in competition on foraging site because the choice made one bird is dependent on choice made by others in a specific habitat.
ii. bird's survival is dependent on its ability to forage very fast and dominate.
iii. local carrying capacity of bird species may be exceeded in isolated areas. This will force more birds to concentrate around limited resources and most bird species may be forced to seek supplementary food source.
iv. migratory distance in trans-Saharan migrants is likely experience maximum prospective increase, whereas species that are restricted to range are anticipated to face key population declines due to homelessness and scattering of birds during migration.
v. hatching failure may occur during breeding season, if the microclimate temperature within the nest cavities is not suitable for breeding.
vi. there may be discrepancy in the scheduling of egg-laying due to warmer spring temperature.
vii. there is every likelihood of bird species developing a fresh migratory approaches and routes with respect to climate alteration.
viii. climate variability may stimulate low productivity and slightly higher mortality in some bird species.
ix. climate variability may bring about reduction in size of habitats utilized by bird species.
x. the quantity and quality of feeding items available to bird species may be affected, and birds may not breed, once there is a decline in quantity and quality of available feeding items.
xi. temperature may stimulate increase in feeding items such as insects and shortage of food may restrict the female from producing eggs, resulting to reduction in breeding performance.
xii. some bird species will be force to adapt, flee or die especially bird species with very narrow home range.
xiii. climate variability may bring about increase in outbreak of pests and diseases.

CONCLUSION AND RECOMMENDATIONS

From all indication, the effects of climate variability on avian species are numerous. Some of the effects of climate change on birds are; alteration in the duration of breeding seasons, alteration in migratory locations, alteration in niche structure, reduction in survival and breeding venture, shifts in timing and duration of breeding, modification of long-term migration and breeding performance, modification of avian morphology, modification of bird's populations, homelessness and scattering of migratory birds, forest-fire, pest and diseases outburst. Effects of climate variability on birds are complicated and species dependent. Understanding how individual species will respond to this global change in the ecosystem will enable avian managers to propose better

conservation measures. Continuous monitoring of birds in changing environmental conditions is necessary in order to understand how individual species will respond to diverse environmental variability.

REFERENCES

Alam, M., Bhatia, R. and Mawby, B. (2015). Women and Alam, M., Bhatia, R. and Mawby, B. (2015). Women and Climate Change: Impact and Agency in Human Rights, Security, and Economic Development, *Published by Georgetown Institute for Women, Peace and Security*, Pp.1-69.

Blondel, J. (2019). How do birds adapt to a changing climate? https://www.encyclopedie-environnement.org/en/life/how-birds-adapt-changing-climate/#:~:text=The%20best%2Dknown%20mechanism%20is,too%20fast%20nor%20too%20high. Accessed 20th March, 2022.

Boere, G.C., Galbraith, C.A. & Stroud, D.A. (eds). (2006). Waterbirds around the world. The Stationery Office, Edinburgh, UK. Pp.960.

Bowler, D., Hof, C., Haase, P. *et al.* (2017). Cross-realm assessment of climate change impacts on species' abundance trends. *Nat Ecol Evol* 1**,** 0067. https://doi.org/10.1038/s41559-016-0067.

Clairbaux, M., Fort, J., Mathewson, P. Porter, W., Strøm, H. and Grémille, D. (2019). Climate change could overturn bird migration: Transarctic flights and high-latitude residency in a sea ice free Arctic. *Sci Rep* 9, 17767 (2019). https://doi.org/10.1038/s41598-019-54228-5.

Crick, H.Q.P. (2004). The impact of climate change on birds. *Ibis* 146 (suppl 1), 48.

Dimitrov, G.B.E. (2019). Effects of Climate change on Women, Research Review *International Journal of Multidisciplinary* 04 (05): 2010 -2015. DOI: http://dx.doi.org/10.5772/intechopen.86912.

Doswald, N., Willis, S. G., Collingham, Y. C., Pain, D. J., Green, R. E., & Huntley, B. (2009). Potential Impacts of Climatic Change on the Breeding and Non-Breeding Ranges and Migration Distance of European Sylvia Warblers. *Journal of Biogeography*, *36*(6), 1194–1208. http://www.jstor.org/stable/40305886.

Dunn, P. (2004). Breeding Dates and Reproductive Performance, *Advances in Ecological Research*, Volume 35, Pages 69-87, https://doi.org/10.1016/S0065-2504(04)35004-X.

Ebele, N. E. and Emodi, N. V. (2016). Climate change and its impact in Nigerian economy. *Journal of Scientific Research & Reports*, 10(6), 1-13. http://www.journaljsrr.com/index.php/JSRR/article/view/21917/40737.

Ecological Niche. (2019). Retrieved from Utexas.edu website: https://web.ma.utexas.edu/users/davis/375/popecol/lec11/niche.html.

Egwumah, F.A. & Iboyi, M.O. (2017) Paramount factors influencing the breeding performance of lovebird *Agapornis pullaria*. *IJLST*, 10, 7, 69-74.

Egwumah, P.O., Agbelusi,E.A. and Egwumah, F.A. (2014). The distribution, abundance and habitat preference of lovebirds *Agapornis pullaria* in Tiotyu riparian vegetation. *Journal of Applied Biosciences* 76: 6361-6367.

Elisha, I., Sawa B. A.and Ejeh U.L. (2017). Evidence of climate change and adaptation strategies among grain farmers in Sokoto State, Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology* (IOSR-JESTFT), 11(3), 1-7.

Enete I.C. (2014). Impacts of climate change on agricultural production in Enugu State, Nigeria. *Journal of Earth Science & Climatic Change*, 5(9), 234. https://www.omicsonline.org/open-access/impacts-of-climate-change-on-agricultural-production-in-enugu-state-nigeria-2157-7617.1000234.php?aid=32633.

Garant, D., Hadfi eld, J.D., Kruuk, L.E.B., and Sheldon, B.C. (2008). Stability of genetic variance and covariance for reproductive characters in the face of climate change in a wild bird population. *Molecular Ecology*, 17:179–188.

Haider, H. (2019). *Climate change in Nigeria: Impacts and responses.* K4D Helpdesk Report 675. Brighton, UK: Institute of Development Studies.

Hällforsa, Maria H., Antãoa, L. H. Itter, M., Lehikoinenc, A., Lindholma, T., Roslina, T., and

Saastamoinena, M. (2020). Shifts in timing and duration of breeding for 73 boreal bird species over four decades, *PNAS* vol. 117 (31): 18557–1856.

Halupka L, Halupka K. (2017). The effect of climate change on the duration of avian breeding seasons: a meta-analysis. *Proc. R. Soc. B* 284: 20171710. http://dx.doi.org/10.1098/rspb.2017.1710.

Heyck-Williams, S. (2019). Climate Change, Natural Disasters, and Wildlife, *National Wildlife Federation*, page: 1-8.

Imlay, T. L., Flemming, J.M., Saldanha, S., Wheelwright, N. T. and Leonard, M. L. (2018). breeding phenology and performance for four swallows over 57 yr: relationships with temperature and precipitation. *Ecosphere* 9(4): 1-15, e02166.10.1002/ecs2.2166.

Jirinec, V., Burner, R.C., Amaral, B.R., Bierregaard Jr, R.O., Fernández-Arellano, G., Hernández-Palma, A., Johnson, E. I. Lovejoy, T.E., Powell, L.L., Rutt, C.L., Wolfe, J.D. and Stouffer, P.C. (2021). Morphological consequences of climate change For Resident birds in intact Amazonian rainforest, *Science Advances*., 7 (46), eabk1743: 1-12 DOI: 10.1126/sciadv. abk1743.

Kaygusuz, K. (2009). Energy and environmental issues relating to greenhouse gas emissions for sustainable development in Turkey. *Renewable and Sustainable Energy Reviews*, 13, 253-270.

Koop, F. (2020). Birds adapt to climate change by changing their body size, study finds, https://www.zmescience.com/science/birds-adapt-to-climate-change-by-changing-their-body-size-study-finds/ Accessed 20th March, 2022.

Meller, K. (2016). The impacts of temperature on the long-term variation in migration and breeding performance of birds a PhD thesis submitted to Faculty of Biological and Environmental Sciences Department of Biosciences, Ecology and Evolutionary Biology University of Helsinki Finland, Page:1-36.

Norman, D. and Peach, W.J. (2013). Density-dependent survival and recruitment in a long- distance Palearctic migrant, the Sand Martin Riparia riparia *Ibis* (2013), 155, 284–296.

Piebeng, G. K., Tamungang, S. A. and Teguia, A. (2017). Breeding biology of African grey parrot (Psittacus erithacus) in Kom National Park (South-Cameroon) and implications to the species conservation. *Int. J. Biol. Chem. Sci.* 11(5): 1948-1966, DOI: 10.4314/ijbcs. v11i5.2

Skagen SK, Adams AA. (2012). Weather effects on avian breeding performance and implications of climate change. *Ecol Appl.*; 22(4):1131-45. doi: 10.1890/11-0291.1. PMID: 22827123.

Stephens, P.A., Mason, L. R., Green, R.E., Gregory, R.D., Sauer, J. R., Alison, J., Aunins, A., Brotons, L., Butchart, S.H. M., Campedelli, T., Chodkiewicz, T., Chylarecki, P., Crowe, O., Elts, J., Escandell, V., Foppen, R.P. B., Heldbjerg, H., Herrando, S., Husby, M., Jiguet, F., Lehikoinen, A., Lindström, Å., Noble, D. G., Paquet, J., Reif, J., Sattler, T., Szép, T., Teufelbauer, N., Trautmann, S., van Strien, A. J. van Turnhout, C. A. M., Vorisek, P. and Willis, S. G. (2016). Consistent response of bird populations to climate change on two continents, *Science*, 352(6281):84-87.

Sulaiman, C. and Abdul-Rahim, A. S. (2018). Population Growth and CO2 Emission in Nigeria: A Recursive ARDL Approach *SAGE Open*, Pp. 1 – 14 DOI: 10.1177/2158244018765916.

Warburton, L.S., and Perrin, M.R. (2006). The Black-cheeked Lovebird *Agapornis nigrigenis* as an agricultural pest in Zambia. *Emu* 106:321-328.

Wiens, J.A., Stralberg, D., Jongsomjit, D., Howell, C.A., and Snyder M. A. (2009). Niches, models, and climate change: Assessing the assumptions and uncertainties, *PNAS*, 106 (2):19729 –19736