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Assessing Environmental Impact of Climate Change on Desert Ecosystems: A Review

Latifa Saeed Al-Blooshi – UAEU

Dr. Salem Essa - UAEU

Prof. Taoufik Ksiksi – UAEU

Outline

- **Climate Change**
 - Changes in climate with time
 - Changes in Atmospheric GHGs
 - Fluctuations in Temperature and Rainfall
- **Climate Change Effect on Desert Ecosystems**
 - The influence on the existence and distribution of ecosystems
 - Climate change is detrimental to deserts
 - Climate change might help deserts
 - Climate change and groundwater
 - Carbon sequestration by land plants



Outline cont.

Species' Response to Climate Change

- Migratory birds
- Bats are bio-indicators of climate change
- Plants

Using RS/GIS to Assess Climate Change on Desert Ecosystems

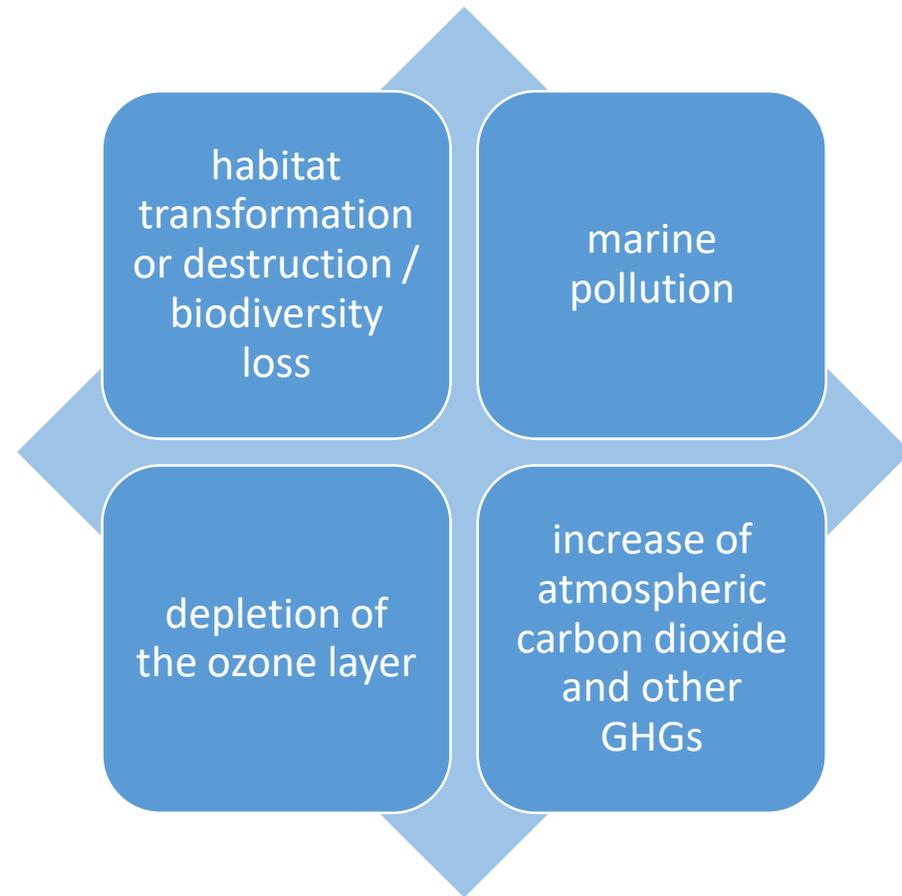
- Applications of Remote Sensing and Geographical Information System

Summary



Climate change

- The root cause of the recent global changes is the great acceleration of population since the 1950s (Paez-Osuna et al., 2016).
- Human interventions led to:



Climate change

- The climate changes are feared to occur in a speed higher than the limits of adaptation in many part of the world.
- The most threatened areas are semi-arid soils.
- The drier of these soils are predisposed to wind erosion when exposed by overgrazing or cultivation.
- Climate change will significantly impact all life sectors in the Gulf region (Al-Maamary et al.,2017).

Climate change (Changes in climate with time)

- Human population increased by 37% and as a result, the atmospheric carbon dioxide levels increased by 9% (Nemani et al., 2003).
- The average global temperature on Earth has increased by about 0.8 °C since 1880. Two-thirds of the warming has occurred since 1975, at a rate of roughly 0.15-0.20 °C per decade. (NASA)

Climate change (Changes in Atmospheric GHGs)

Annually release
over 29 billion
metric tons of
carbon dioxide

GHGs
concentrations
have increased
by 35 % for
carbon dioxide,
148 % for
methane, and
14 % for nitrous
oxide

Increases in
GHGs and
temperature is
the highest
compared to the
past 650,000
years

Source: (Rustad, 2008), (Williams et al., 2012)

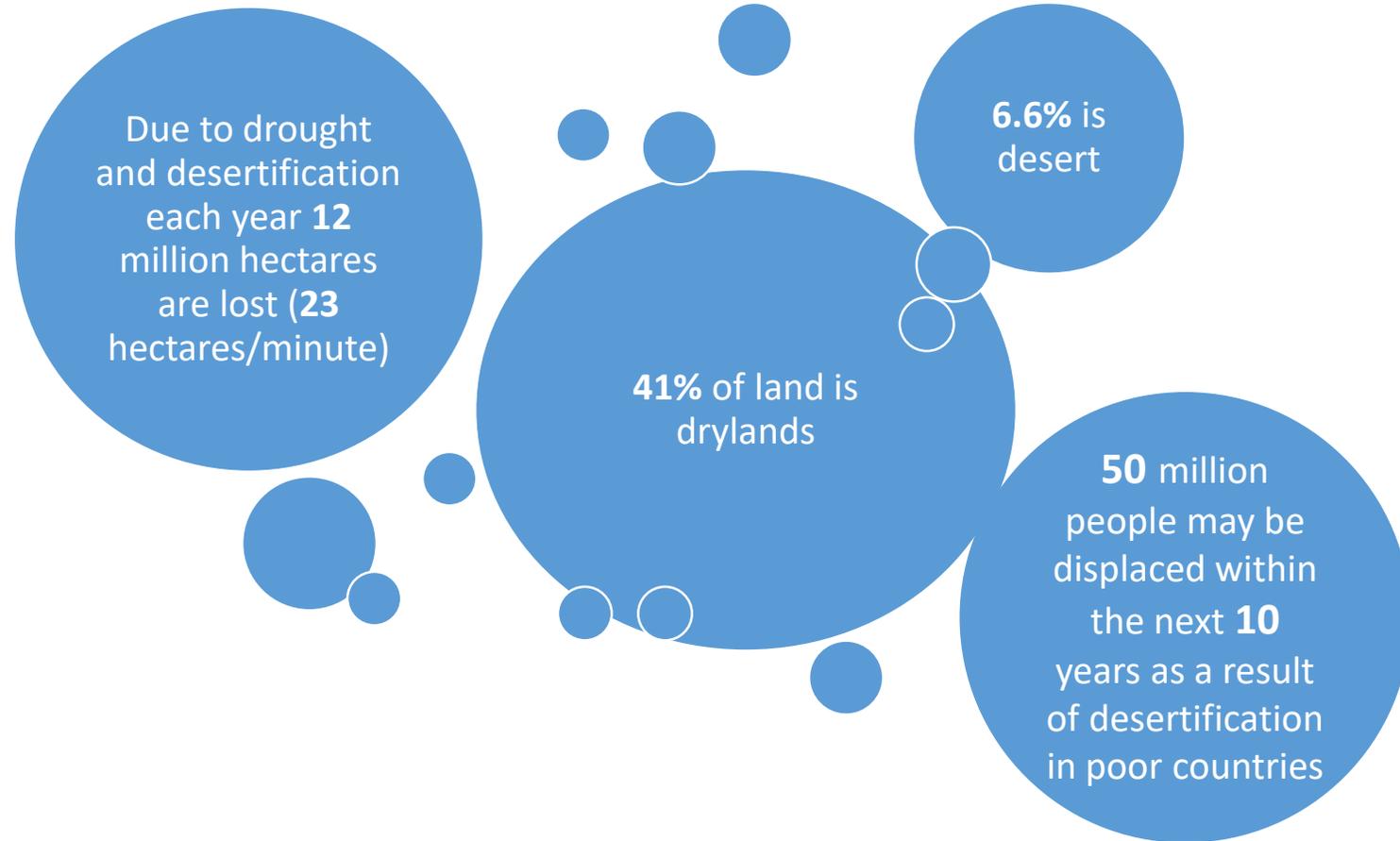
Climate change (Changes in Atmospheric GHGs)

- It is believed that changes in climate due to increased earth temperature may affect agricultural water demand, because of the effect of climatic variables on earth's temperature.
- Around 6 to 8% is the damage to crop due to climate change in the developed countries. Compared to the situation in developing countries, the percentage is very low (Al-Amin and Ahmed, 2016).

Climate change (Fluctuations in Temperature and Rainfall)

- A very important possible driver of future wind erosion and dust storm occurrence is climate change, that is via the episodes of intense wind events.
- Western North America, has lately lost 63 trillion gallons of surface water due to enduring drought (Hall et al., 2016).
- Drought reoccurrence and rigorousness are expected to increase crosswise several continents.
- Fluctuation in rainfall and temperature rates would strongly influence the existence and distribution of specific ecosystems, plant species and patterns of natural resource systems.

Climate change effects on desert ecosystems



Climate change effect on desert ecosystems

(Existence and distribution of ecosystems)

- Desert ecosystems are highly variable and unpredictable, where organisms and humans have utilized arid environments regardless of their naturally uncertain availability of resources.
- Species with high functional richness present a diversity of plant growth strategies. They should be better placed to be able to meet the challenges of future climate change by interacting with ecosystem functionality and enhancing the adaptive capacity of ecosystems (Freudenberger et al. 2012).

Climate change effect on desert ecosystems

(Climate change is detrimental to deserts)



- Poorly managed soils are exposed to degradation and they are vulnerable to become infertile as a result of climate change.
- In desert zones, temperature increases would have harmful impacts on vegetation.
- As a result, plants with surface root systems, which depends on rainfall, will be at risk (Sivakumar, 2007).
- Researchers predict that the deserts of North America will become warmer and drier at a fast rate.

Climate change effect on desert ecosystems (Climate change might help deserts)

- Terrestrial ecosystems store a large amount of carbon, approximately three times that of the atmosphere.
- Including carbon dioxide fertilization in the simulations, produced a decrease in desert area, as the higher carbon dioxide levels allow the plants to prevent the increased aridity in an effective way.
- Lots of experiments showed that increased CO₂ concentrations can increase photosynthesis and growth, and reduce stomatal conductance (Jarvis and Aitken, 1998).
- The response is varied between different species and experimental conditions.

Climate change effect on desert ecosystems (Climate change and groundwater)



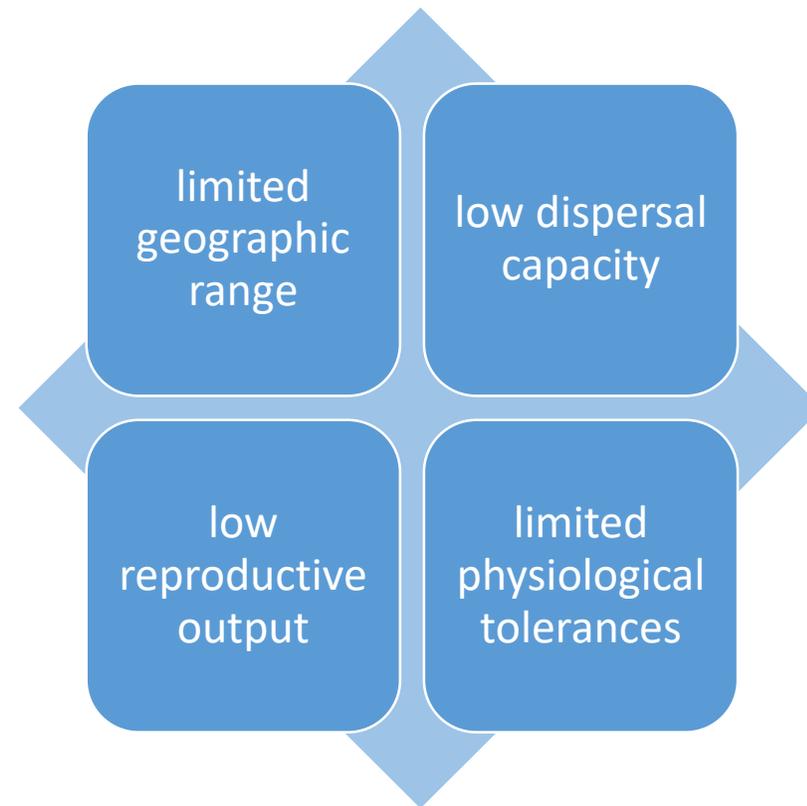
- Several areas of the Gulf countries depend heavily on groundwater.
- The future estimations have shown that all the countries will be suffering from a lack of water availability (Menzel and Matovelle, 2010).
- Groundwater recharge usually engages a deep drainage function connected to the provision of two ecosystem services: water filtration/ water cleaning, and freshwater supply from underground aquifers.

Climate change effect on desert ecosystems (Carbon sequestration by land plants)

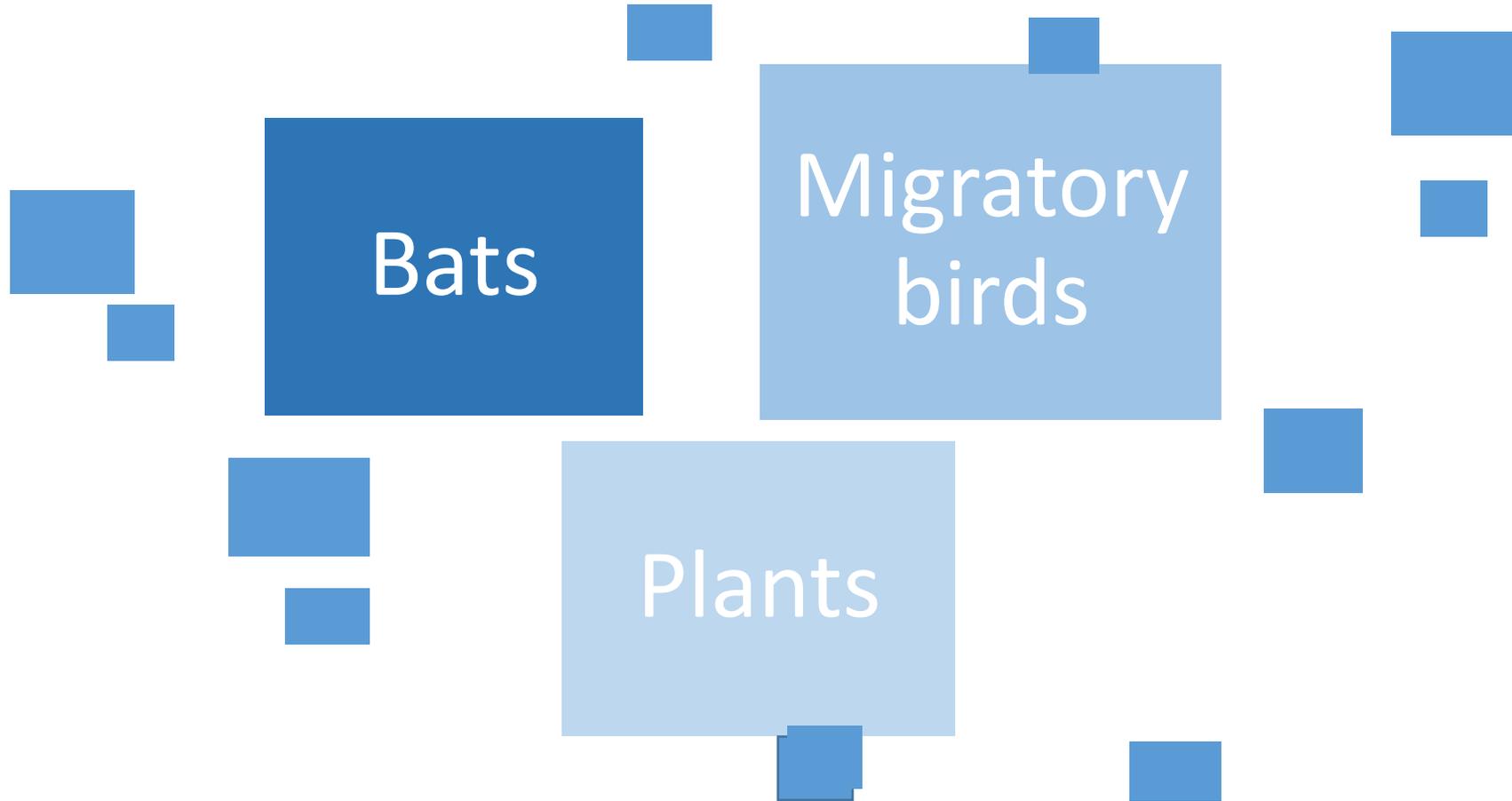
- Terrestrial ecosystems sequester 20 – 30 % of global CO₂ emissions and play a key role in global carbon cycling (Saleska et al.,2003).
- Rangelands (including grasslands, shrublands, deserts and tundra) covers about 50% of the world's land area, and contain about 35% of above- and below-ground carbon reserves (Schuman et al., 2002).
- Carbon sequestration would increase over time due to the increase in woody plants.

Climate change effect on species

- The most affected species are those with narrow niche breadth (Schloss et al., 2012).
- Highly threatened by changes in climates because of their;

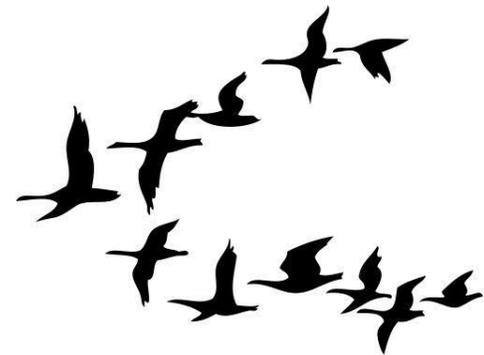


Climate change effect on species



Climate change effects on species

- **Migratory birds:** Climatic changes put migratory birds at greater risk of extinction than permanent resident birds (Cox, 2010).
- Dependence on habitats and resources in a wide range of areas at different stages of their annual cycles.
- Their nature of using various habitats or geographical areas at different time periods.
- That interactions between temperature, precipitation rate or other factors influence changes in the distributions of the migratory birds



Climate change effect on species

- **Bats:** Are considered as bio-indicators of climate change due to their sensitivity to environmental conditions (Hall et al., 2016).
- During times of extended drought periods, bats have experienced declination in reproduction and undersized young.
- The experimental findings discovered that smaller water surface areas affected drinking success and timing of use by less-maneuverable bats.



Climate change effect on species

- **Plants:** The effects of climate warming on desert plants is as yet not very well known. It is due to the general belief that desert vegetation will expand as consequence of climate change.
- It is believed that some deserts will potentially expand and Fynbos will be reduced.
- Tropics may move northward for cooler areas because of Climate change (Corlett, 2012).



Using RS/GIS to assess climate change on desert ecosystems

GIS/RS Applications

land use\cover
classification

Detect change
in landscape

Detect loss of
habitats

Simulate
future
changes

Indicate
groundwater
potential

Assess
drought
condition

Using RS/GIS to assess climate change on desert ecosystems



- The application of remotely sensed data could make a significant difference in drought monitoring and drought prediction, which is critical for governments to mitigate realistic measures in progress.
- (Alshaikh. 2015) conducted a study to monitor and assess the drought condition in Wadi-Dama, north KSA, in 1990 and 2013 using satellite remote sensing data analysis and GIS technology.
- (Thakkar, et al. 2016) improved the classification accuracy in the arid heterogeneous landscape of Arjuni watershed, India, using RS and GIS.

Using RS/GIS to assess climate change on desert ecosystems



- Using remote sensing data, (Ghadiry, et al. 2012) developed a new GIS-based model for automated extraction of sand dune encroachment and for assessing the rate of sand dune movement.
- (Abdalla. 2012) determined the most important contributing parameters for indicating the groundwater potential such as slope, stream networks, lineaments, lithology and topography, where a thematic map of each parameter was produced using GIS and RS techniques

Summary

- The human population increased by 37% and as a result, the atmospheric carbon dioxide levels increased by 9%.
- Terrestrial ecosystems sequester 20 - 30% of global anthropogenic CO₂ emissions and play a key role in global carbon cycling.
- The effects of climate change on biodiversity is generally slow, but these effects are expected to show high progress over the next 50 years and beyond.

Summary cont.

- Tropics may move northward for cooler areas because of Climate change.
- There are different application of RS/GIS to assess climate change on desert ecosystems such as drought, sand dune movement and groundwater.
- Most of the found papers are for studies done out of the Arabian region. More studies are needed for the Arabian Gulf countries.





Thank you