6.3 Applications of remote sensing and GIS in habitat analysis

Remote sensing (RS) and geographic information systems (GIS) have revolutionized habitat analysis by enabling large-scale mapping and monitoring of environmental variables relevant to mosquito ecology. High-resolution satellite imagery facilitates identification of potential breeding sites such as water bodies, vegetation cover, and urban infrastructure features that influence habitat suitability (Javed et al., 2024). GIS platforms integrate spatial data layers including climate variables, land use patterns, and vector occurrence records to model habitat distribution and predict hotspots for targeted interventions. These technologies enhance understanding of landscape-level drivers shaping mosquito populations beyond localized field surveys.

Emerging applications combine RS/GIS with behavioral monitoring tools to provide dynamic assessments of vector activity patterns over time (Javed et al., 2024). This integration supports adaptive management by allowing real-time evaluation of control measures' effectiveness across heterogeneous environments. Moreover, spatial analyses assist in stratifying risk areas based on environmental correlates derived from remotely sensed data, improving resource allocation efficiency (Kampen et al., 2015). Despite their potential, challenges remain regarding data resolution limitations and the need for ground-truthing to validate remote observations. Nonetheless, RS and GIS represent indispensable components of modern entomological research frameworks aimed at controlling mosquito-borne diseases effectively.

7 Results and Discussion

7.1 Correlation analysis between seasonal dynamics and environmental variables

Seasonal dynamics of mosquito populations show strong correlations with environmental variables such as temperature, precipitation, and habitat type, which collectively influence population fluctuations over time. Studies on other taxa in aquatic and terrestrial ecosystems reveal that population densities often peak during seasons with optimal climatic conditions; for example, bird populations increased by 65% in spring compared to fall, linked to habitat composition and seasonal factors (Azizoğlu et al., 2023). Similarly, scorpion foraging activity and microhabitat colonization vary seasonally, reflecting climatic impacts on population dynamics through resource availability and refuge use (Lira et al., 2018). These patterns suggest that mosquito populations likely respond similarly to seasonal environmental changes, with temperature and rainfall driving breeding site availability and survival rates (Figure 4).

Temporal variation in habitat quality also shapes species distribution and abundance by altering resource availability across seasons. Research on waterbirds demonstrated that seasonal deterioration of habitat quality leads to weakened distribution-abundance relationships later in the summer due to habitat homogenization (Charalambous et al., 2024). Migratory species exhibit seasonal shifts in habitat selection aligned with life-history stages, indicating that spatial distribution is dynamic and influenced by both local and landscape-scale environmental heterogeneity (Stanley et al., 2021). These findings underscore the importance of incorporating multiple environmental variables and temporal scales when analyzing mosquito seasonal dynamics to capture complex ecological responses accurately.

7.2 Relationships between habitat characteristics and population distribution

Habitat characteristics such as vegetation structure, water availability, and human disturbance strongly influence mosquito population distribution by affecting breeding site suitability and resource access. Studies on diverse taxa highlight that species richness and functional diversity differ between wet and dry habitats due to microhabitat preferences; for instance, scorpions showed higher functional richness in wet forests compared to semiarid areas, reflecting habitat-driven spatial segregation (Lira et al., 2018). Similarly, waterfowl populations varied significantly among habitats like open water surfaces versus reed beds, indicating that specific habitat types support different population densities (Azizoğlu et al., 2023). These patterns imply that mosquito species distributions are closely tied to fine-scale habitat features that determine larval development success and adult survival.