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Integrating Earth Observation and Multi-Agent Modelling to Assess Climate and Land-Use Impacts on Large Herbivore Movement in Amboseli, Kenya

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Large herbivores, like other living organisms, are susceptible to environmental degradation, climate extremes, and anthropogenic activities. As heterotrophic primary consumers, they depend on vegetation and water resources, which require seasonal and spatial movement within ecosystems to meet nutritional and reproductive needs. Frequent climate extremes, such as recurrent droughts, disrupt ecosystem functioning. These disruptions lead to habitat degradation, altered movement patterns, increased disease incidence, and higher wildlife mortality.

In the Amboseli ecosystem in Kenya, large herbivores, both wild and domesticated, including elephants (Loxodonta africana), giraffes (Giraffa camelopardalis), zebras (Equus quagga), and cattle (Bos taurus), experience compounded ecological and anthropogenic pressures. These pressures, including the shift toward sedentary land use, land subdivision, and urbanization, have further restricted animal movement and reduced access to forage and water resources.

This study integrates Earth observation and environmental datasets to evaluate the dynamics of ecological and human activities. Using Sentinel-2 imagery, we derived vegetation indices (EVI, NDVI, and MSAVI) and the water index (NDWI). These indices were supplemented with data on rainfall, elevation, temperature, road networks, human settlements, and the 2024 land-cover classification. These data, together with the in situ animal species location data collected in May 2024, were incorporated into a multi-agent-based modeling approach using the Ocelet language and platform to simulate the movement of elephants, giraffes, zebras, and cattle within the ecosystem.

The results reveal species-specific spatial interactions, preferred habitat zones, areas of ecological disruption, and potential movement corridors and barriers. This integrative approach provides

insights into the effects of climate variability and land-cover change on animal movement and ecosystem health.