Responses of ecosystem assimilation and respiration to global climate change vary considerably among terrestrial ecosystems constrained by both biotic and abiotic factors. In this study, net CO_2 exchange between ecosystem and atmosphere (NEE) was measured over a 4-year period (2013–2016) using eddy covariance technology in an ecosystem in Central Asia. Ecosystem assimilation (gross primary production, GPP) and respiration (R_{eco}) were derived from NEE by fitting light response curves to NEE data based on day- and nighttime data, and their responses to soil water content (SWC) and evaporative fraction (EF) were assessed during the growing season. Results indicated that both GPP and R_{eco} linearly decreased with declining SWC, with the sensitivity of GPP to SWC being 3.8 times higher than that of R_{eco} during the entire growing season. As a result, ecosystem CO_2 sequestration capacity decreased from 4.00 μmol m^{-2} s^{-1} to 1.00 μmol m^{-2} s^{-1}, with increasing soil drought. On a seasonal scale, significant correlation between GPP and SWC was only found in spring while that between R_{eco} and SWC was found in all growing seasons with the sensitivity increasing steadily from spring to autumn. EF had a low correlation with SWC, GPP and R_{eco} (R^2 = 0.03, 0.02, 0.05, respectively), indicating that EF was not a good proxy for soil drought and energy partitioning was not tightly coupled to ecosystem carbon exchanges in this desert ecosystem. The study deepens our knowledge of ecosystem carbon exchange and its response to drought as well as its coupling with ecosystem energy partitioning in an extreme dry desert. The information is critical for better assessing carbon sequestration capacity in dryland, and for understanding its feedback to climate change.