Appendix II: Supplemental Plots

Transmission Parameter Curves by Approach

The following functions represent how temperature affects key transmission parameters. For Approach A, the mosquito biting rate (a) is derived from studies on *Anopheles pseudopunctipennis* vectors [1, 26, 44, 45], and the mortality rates (μ_l and μ_m) were defined using data from *Culex quinquefasciatus and Aedes aegypti* mosquitoes [43]. Figure S1 provides plots showing how these parameters change with temperature.

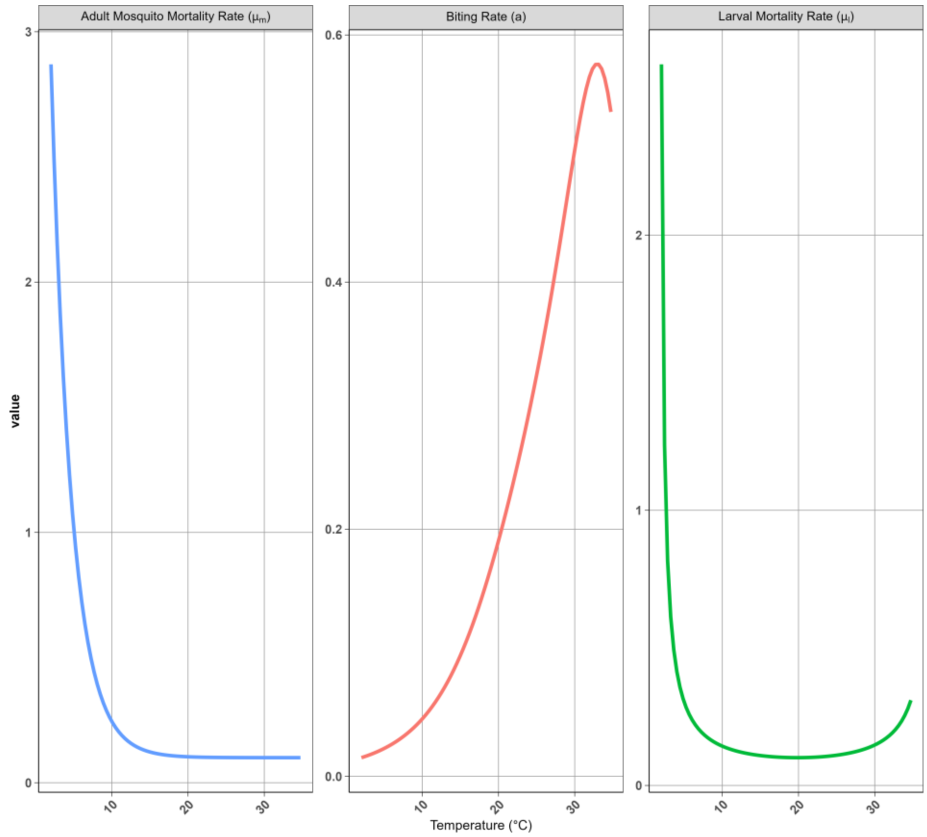

Fig. S1: Model parameters used for Approach A.

Figure S2 shows thermally driven changes in egg production (n_e), oviposition (ϑ), development (κ_e, κ_l, and κ_p), and mortality (μ_e and μ_l), were parameterized for *A. arabiensis* [22, 39] in Approach B. These processes were captured through cubic polynomial functions constrained to biologically plausible values. The mosquito biting rate (a) follows a non-linear thermal response drawing on empirical relationships for *Anopheles spp.* and *A. pseudopunctipennis* [22, 41].

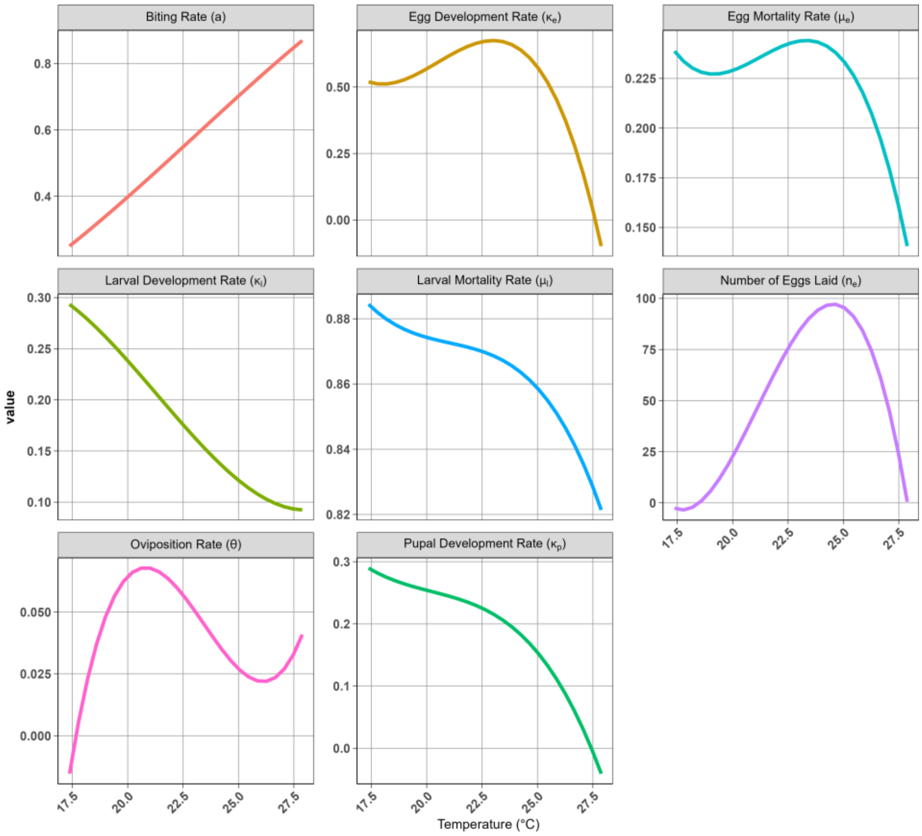

Fig. S2: Model parameters used for Approach B.

Figure S3 shows how in Approach C, the larval mortality rate (μ_l), adult mortality rate (μ_m), parasite development rate (γ_m), and biting rate (a) are defined using the following non-linear thermal functions. These functions were parameterized from studies of *Anopheles spp.* and the *A. gambiae* complex [22, 25, 40, 42], alongside biting rate relationships informed by *A. pseudopunctipennis* [22, 41].

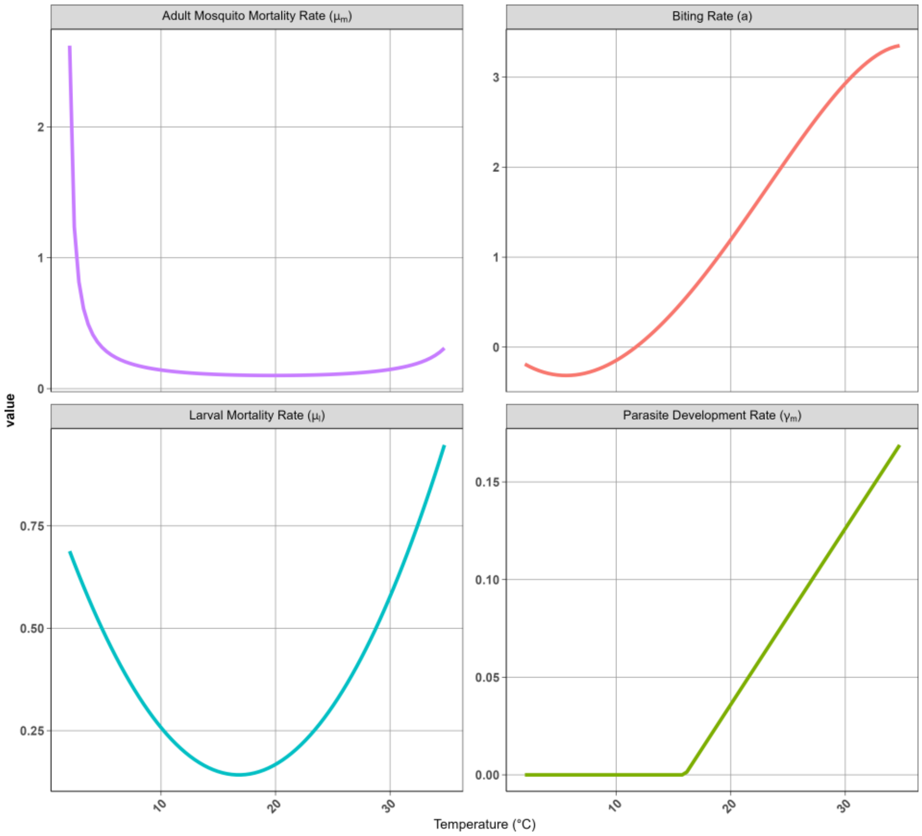

Fig. S3: Model parameters used for Approach C.

Surface Responses to Temperature and Rainfall (Approach C)

Figure S4 shows that the carrying capacity (K_m) for mosquito breeding increases linearly with rainfall, reflecting resource availability.

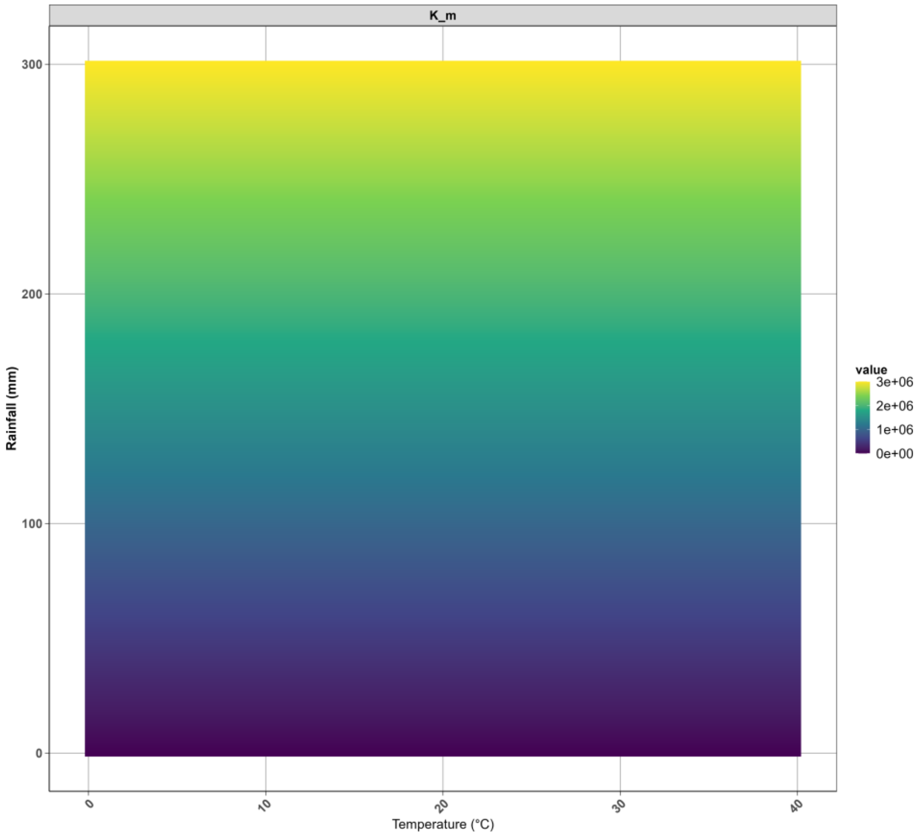

Fig. S4: Adult carrying capacity profile used for Approach C.

Surface plots of egg, larval, and pupal development rates (κ_e, κ_l, and κ_p) derived from studies on *A. gambiae* complex mosquitoes show complex interactions between climatic variables under Approach C [22, 25, 40, 42].

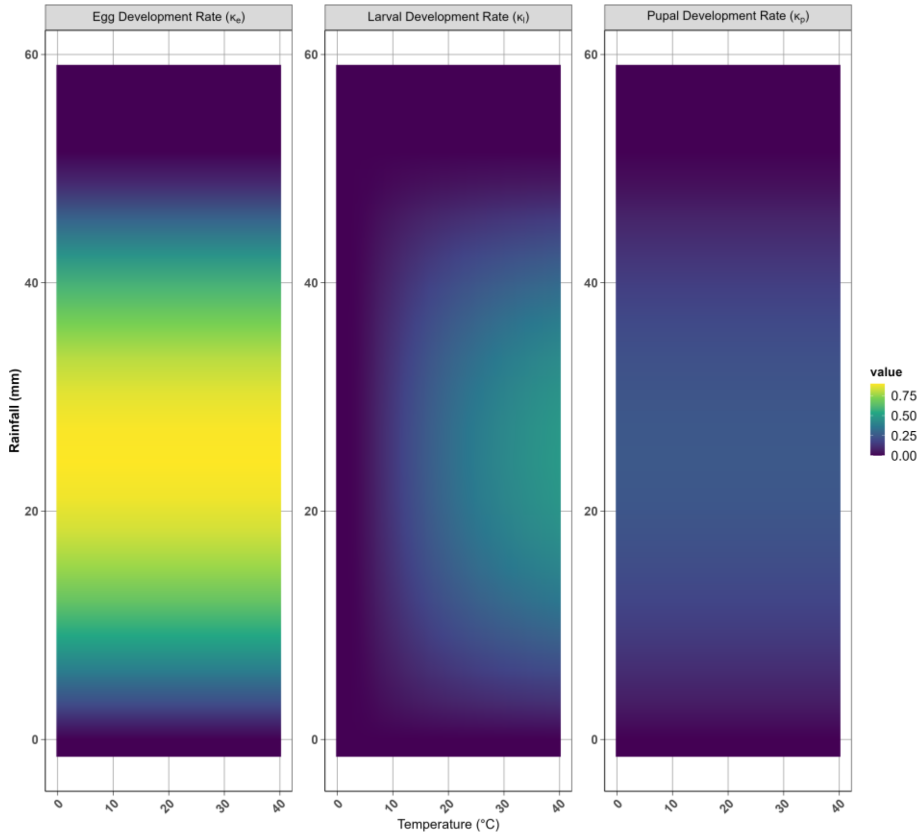

Fig. S5: Survival rate profiles for eggs, larvae and pupae used for Approach C.

Table S2: Summary of functional forms used in each approach.

Symbol	Description	Function	Approach
a	Adult mosquito biting rate	$\frac{1.25}{107.204 - 13.3523T + 0.677509T^2 - 0.0159732T^3 + 0.000144876T^4}$	A
μ_l	Larval mortality rate	$\max\left(0, \frac{1}{-4.4 + 1.31(T+2) - 0.03(T+2)^2}\right)$	A
μ_m	Mortality rate in adult mosquitoes	$\frac{3.04}{30.4} + \frac{29.564}{30.4} \times \exp\left(-\frac{T + 273.15 - 278}{2.7035}\right)$	A
a	Adult mosquito biting rate	$2.5 \times 0.000203 \times (T^2 - 11.7T) \times \sqrt{42.3 - T}$	B
n_e	Total number of eggs laid	$-3.387987 + 1.038248 \times (-0.61411T^3 + 38.93T^2 - 801.27T + 5391.4)$	B
θ	Egg laying rate	$-7.648455 + 1.147739 \times (0.00054T^3 - 0.038T^2 + 0.88T)$	B
κ_e	Egg hatching rate	$-0.3485345 - 0.2186501 \times (0.012(T+2)^3 - 0.81(T+2)^2 + 18(T+2) - 135.93)$	B
μ_e	Egg mortality rate	$0.2874394 - 0.1396794 \times (0.0033(T+2)^3 - 0.23(T+2)^2 + 5.3(T+2) - 40)$	B
κ_l	Larval development rate	$0.4722003 - 0.09495794 \times (-0.002(T+2)^3 + 0.14(T+2)^2 - 3(T+2) + 22)$	B
μ_l	Larval mortality rate	$1.115093 - 0.1583374 \times (0.00081(T+2)^3 - 0.056(T+2)^2 + 1.3(T+2) - 8.6)$	B
κ_p	Pupal development rate	$0.3881068 + 0.2755463 \times (-0.0018(T+2)^3 + 0.12(T+2)^2 - 2.7(T+2) + 20)$	B

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a	Adult mosquito biting rate	$7.5 \times 0.000203 \times (T^2 - 11.7T) \times \sqrt{42.3 - T}$	C
K_m	Adult mosquito carrying capacity	$10^4 \times R$	C
κ_e	Egg hatching rate	$\min\left(1, \frac{4 \times \text{max}p_e}{R_l^2} \times R \times \max(0, R_l - R)\right)$	C
t_l	Larval development period	$0.0557(T + 2) - 0.06737$	C
κ_l	Larval development rate	$\exp\left(-\frac{1}{t_l}\right) \times \min\left(1, \frac{4 \times \text{max}p_l}{R_l^2} \times R \times \max(0, R_l - R)\right)$	C
κ_p	Pupal development rate	$\min\left(1, \frac{4 \times \text{max}p_p}{R_l^2} \times R \times \max(0, R_l - R)\right)$	C
μ_l	Larval mortality rate	$0.0025(T + 2)^2 - 0.094(T + 2) + 1.0257$	C
μ_m	Mortality rate in adult mosquitoes	$\max\left(0, \frac{1}{-4.4 + 1.31T - 0.03T^2}\right)$	C
γ_m	Parasite development rate in infected mosquitoes	$\max\left(0, \frac{T - 16}{111}\right)$	C

Climate Data

Figure S7 provides a timeseries of mean monthly temperature trends from the Climate Change Knowledge Portal (CCKP) are shown across the semi-arid, tropical, and sub-tropical regions.

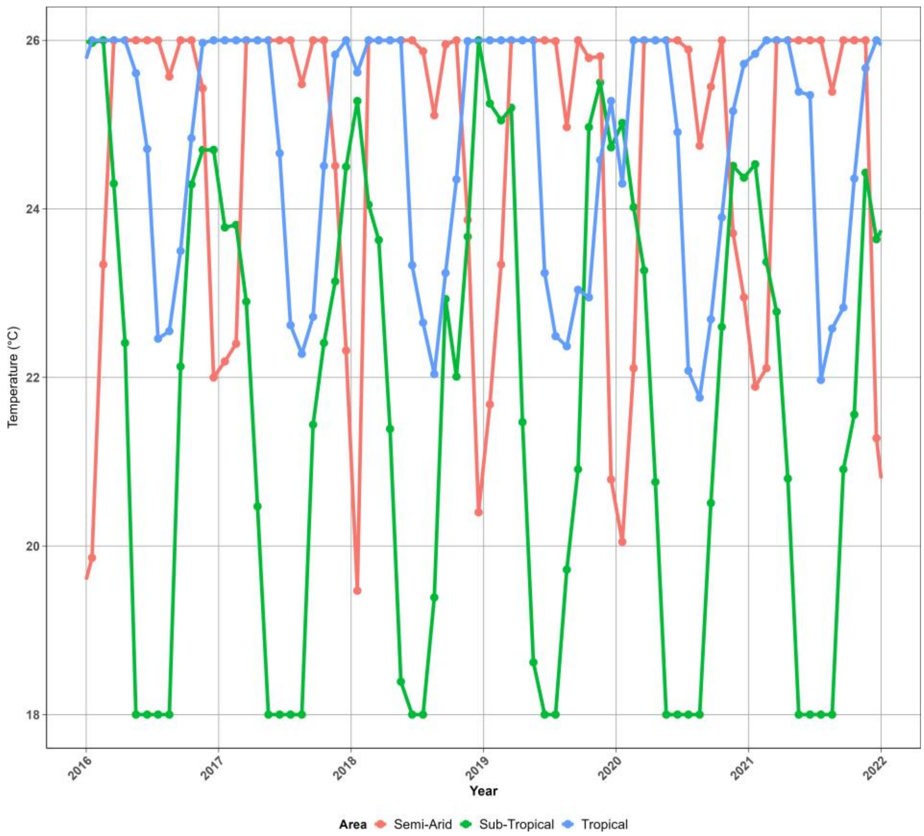

Fig. S7: Temperature trends for the 2016 to 2022 period

Figure S8 provides a timeseries of mean monthly rainfall trends from the Climate Change Knowledge Portal (CCKP) are shown across the semi-arid, tropical, and sub-tropical regions.

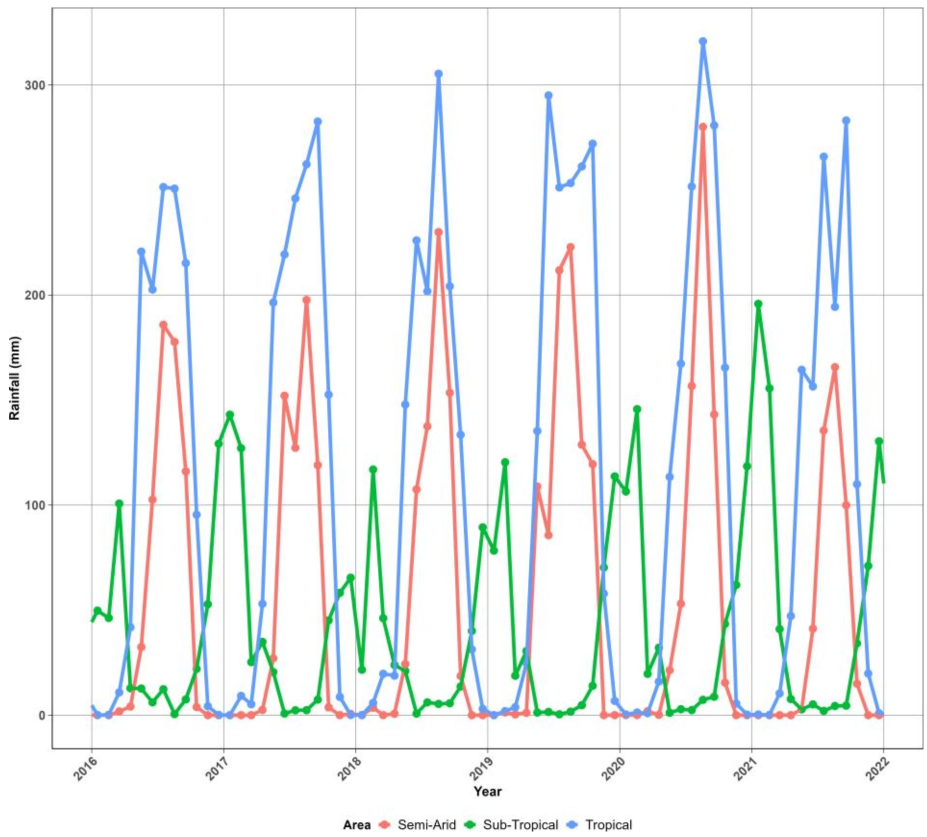

Fig. S8: Rainfall trends for the 2016 to 2022 period

Time-Series of Derived Parameters by Approach

Temperature-derived values of biting rate and mortality over time across semi-arid, tropical, and sub-tropical regions.

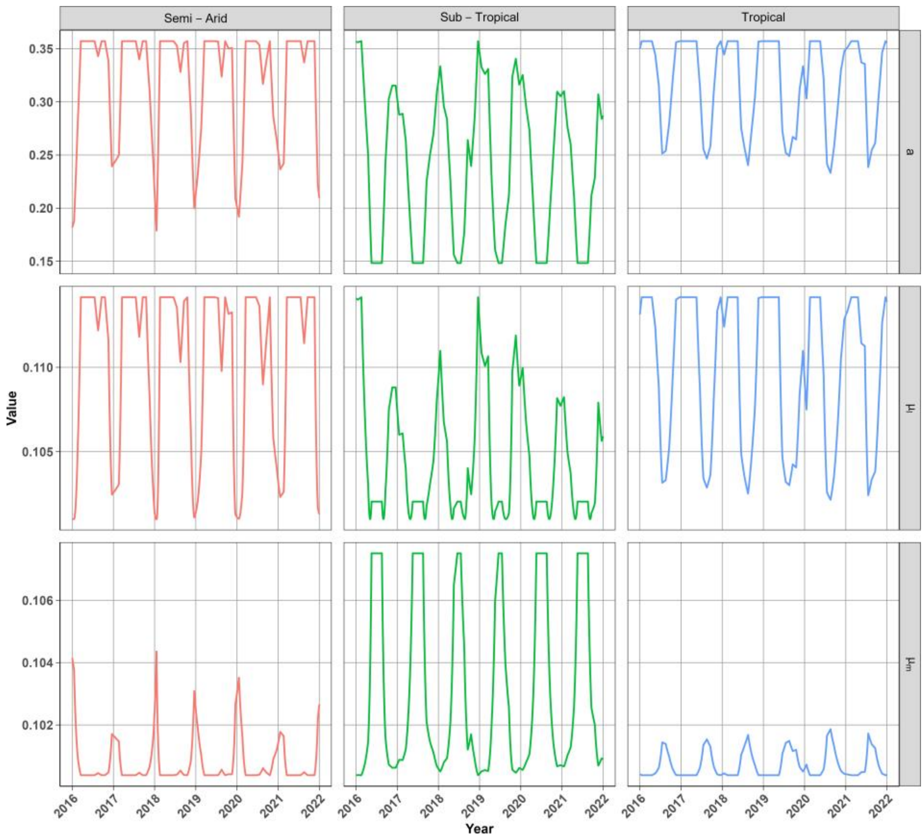

Fig. S9: Model parameters used for Approach A.

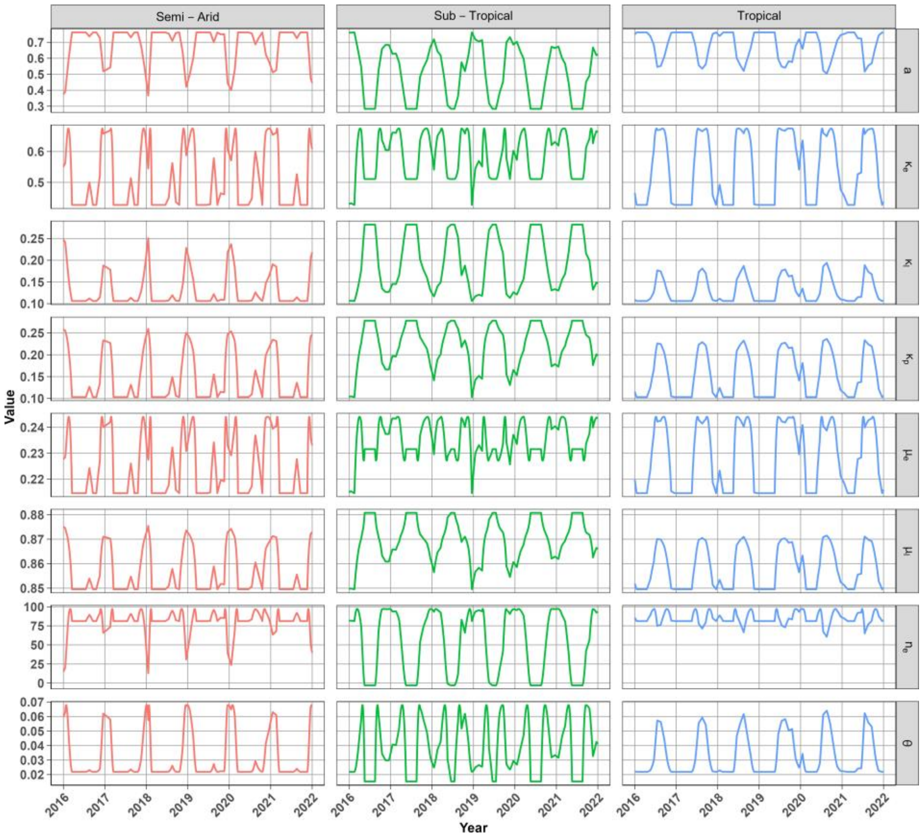

Fig. S10: Model parameters used for Approach B.

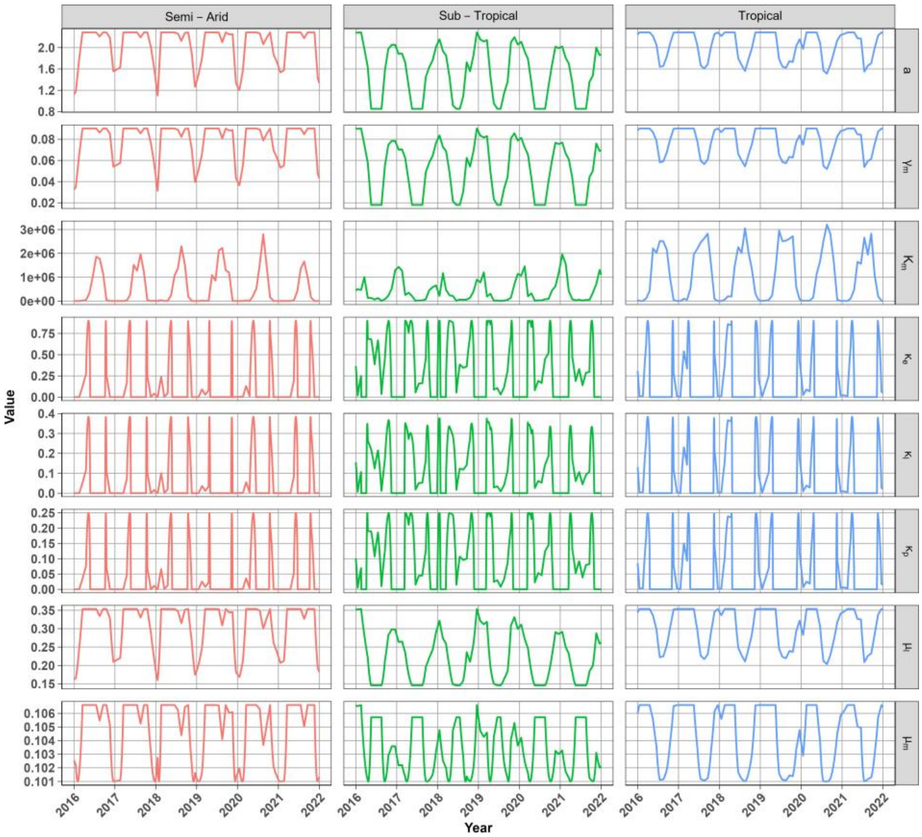

Fig. S11: Model parameters used for Approach C.