$$\frac{dS_i}{dt} = \mu_i N_i - a_i b_i S_i \frac{I_{sv}}{N_i} - a_i b_i S_i \frac{I_{rv}}{N_i} + \sigma_i R_i - \lambda_i S_i \tag{1}$$

$$\frac{dE_{si}}{dt} = a_i b_i S_i \frac{I_{sv}}{N_i} - \varepsilon_i E_{si} - \lambda_i E_{si} \tag{2}$$

$$\frac{dE_{ri}}{dt} = a_i b_i S_i \frac{I_{rv}}{N_i} - \varepsilon_i E_{ri} - \lambda_i R_{ri} \tag{3}$$

$$\frac{dI_{si}}{dt} = \varepsilon_i E_{si} - \tau_i I_{si} - \gamma_i I_{si} - \lambda_i I_{si} \tag{4}$$

$$\frac{dI_{ri}}{dt} = \varepsilon_i E_{ri} - \tau_i I_{ri} - \gamma_i I_{ri} - \lambda_i I_{ri} \tag{5}$$

$$\frac{dT_{si}}{dt} = \tau_i I_{si} - \gamma_{its} T_{si} - \eta_i T_{si} - \lambda_i T_{si} \tag{6}$$

$$\frac{dT_{ri}}{dt} = \tau_i I_{ri} - \gamma_{itr} T_{ri} + \eta_i T_{ri} - \lambda_i T_{ri} \tag{7}$$

$$\frac{dR_i}{dt} = \gamma_i I_{si} + \gamma_i I_{ri} - \sigma_i R_i - \lambda_i R_i \tag{8}$$

$$\frac{dS_w}{dt} = \mu_w N_w - a_w b_w S_w \frac{I_{sv}}{N_w} - a_w b_w S_w \frac{I_{rv}}{N_w} + \sigma_w R_w - \lambda_w S_w \tag{9}$$

$$\frac{dE_{sw}}{dt} = a_w b_w S_w \frac{I_{sv}}{N_w} - \varepsilon_w E_{sw} - \lambda_w E_{sw} \tag{10}$$

$$\frac{dE_{rw}}{dt} = a_w b_w S_w \frac{I_{rv}}{N_w} - \varepsilon_w E_{rw} - \lambda_w R_{rw} \tag{11}$$

$$\frac{dI_{sw}}{dt} = \varepsilon_w E_{sw} - \gamma_w I_{sw} + \eta_w I_{sw} - \lambda_w I_{sw} \tag{12}$$

$$\frac{dI_{rw}}{dt} = \varepsilon_w E_{rw} - \gamma_w I_{rw} - \eta_w I_{sw} - \lambda_w I_{rw} \tag{13}$$

$$\frac{dR_w}{dt} = \gamma_w I_{sw} + \gamma_w I_{rw} - \sigma_w R_w - \lambda_w R_w \tag{14}$$

$$\frac{dS_v}{dt} = \mu_v N_v - e^{-\lambda T} \sum_{i=1}^{D} c_i a_i \frac{I_{si}}{N_i} S_v - e^{-\lambda T} \sum_{i=1}^{D} c_i a_i \frac{I_{ri}}{N_i} S_v - e^{-\lambda T} \sum_{w=1}^{W} c_i a_i \frac{I_{sw}}{N_w} S_v - e^{-\lambda T} \sum_{w=1}^{W} c_i a_i \frac{I_{rw}}{N_w} S_v - \lambda_v S_v \tag{15}$$

$$\frac{dE_{sv}}{dt} = e^{-\lambda T} \sum_{i=1}^{D} c_i a_i \frac{I_{si}}{N_i} S_v + e^{-\lambda T} \sum_{w=1}^{W} c_i a_i \frac{I_{sw}}{N_w} S_v - \varepsilon_v E_{sv} - \lambda_v E_{sv} \tag{16}$$

$$\frac{dE_{rv}}{dt} = e^{-\lambda T} \sum_{i=1}^{D} c_i a_i \frac{I_{ri}}{N_i} S_v + e^{-\lambda T} \sum_{w=1}^{W} c_i a_i \frac{I_{rw}}{N_w} S_v - \varepsilon_v E_{rv} - \lambda_v E_{rv} \tag{17}$$

$$\frac{dI_{sv}}{dt} = \varepsilon_v E_{sv} - \lambda_v I_{sv} \quad (18)$$

$$\frac{dI_{rv}}{dt} = \varepsilon_v E_{rv} - \lambda_v I_{rv} \quad (19)$$