\[ J_{sA} = E_{sA} / E_{pA} \]  
\[(49a)\]

The field irrigation sufficiency of the group B crop(s) is similarly calculated as:

\[ J_{sB} = E_{sB} / E_{pB} \]  
\[(49b)\]

The total irrigation sufficiency becomes:

\[ J_{st} = (J_{sA} A + J_{sB} B) / (A + B) \]  
\[(49c)\]

Irrigation can be:

1. efficient and sufficient
2. inefficient but sufficient
3. efficient but insufficient
4. inefficient and insufficient

The product of efficiency and sufficiency is a measure for irrigation effectiveness. The effectiveness of field irrigation for the land under group A crops is:

\[ J_{eA} = F_{IA} J_{sA} \]

The effectiveness of field irrigation for the land under group B crops is:

\[ J_{eB} = F_{IB} J_{sB} \]

and the total field irrigation effectiveness becomes:

\[ J_{et} = (A J_{eA} + B J_{eB}) / (A + B) \]

The irrigation sufficiencies, efficiencies and effectiveness are a tool to judge variations in agricultural and water management practices on irrigation performance.

4. Salt balance equations

4.1 Change in salt content

The salt balances are, like eqn. 1, based on:

\[ \text{incoming salt} = \text{outgoing salt + storage of salt} \]

In addition we have:

- incoming salt = inflow \( \times \) salt concentration of the inflow
- outgoing salt = outflow \( \times \) salt concentration of the outflow
- salt concentration of the outflow = leaching efficiency \times \text{time averaged salt concentration of the water in the reservoir of outflow}

- change in salt concentration of the soil = \text{salt storage} \div \text{amount of water in the soil}

Hence, the salt balances are based on the water balances.

In Saltmod, the salt balances are calculated separately for the different reservoirs and, in addition, for different types of crop rotation, indicated by the key $K_r$ which can reach the values 0, 1, 2, 3, and 4. $K_r = 0$ indicates that there is no annual crop rotation and all land use types are fixed to the same areas each year. $K_r = 4$ indicates that there is full annual crop rotation and that the land use types are continually moved over the area. The other values of $K_r$ indicate intermediate situations which are explained elsewhere.

The time averaged salt concentration of the percolating water is calculated according to the theory of leaching.

In the following, all salt concentrations are expressed as electric conductivity (EC) in dS/m. Salt concentrations of soil moisture are given on the basis of saturated soil. Quantities of salt, being the product of an amount of water in m/season and a concentration in dS/m, are expressed in dS/season.

### 4.2 Salt leaching

When the soil is being desalinised by percolation (leaching) one usually obtains an exponentially decreasing salinity in the course of time (e.g. van Hoorn and van Alphen, 1994). The graphic presentation of this phenomenon is called leaching curve or salinity depletion curve (fig. 6).

The salt concentration ($C_i$ dS/m) of the water percolating from a reservoir can be taken proportional to the salt concentration in the reservoir ($C_r$, dS/m):

$$C_i = F_i C_r$$

where the factor $F_i$ is called leaching efficiency.

The change of the salt concentration $C_i$ can be described by the differential equation:

![Figure 6. The leaching curve and the geometric mean of soil salinity in a time interval](image)
where: $P_t$ is the total porosity fraction (-) of the reservoir, $D$ is the thickness (m) of the reservoir, $L$ is the percolation velocity (m per unit of time), and $t$ is the time (any unit).

Using eqn. 49 and writing $\alpha = LFCrI / P_tD$, the above equation can be changed into:

$$
\frac{dC_r}{dt} = -\alpha C_r
$$

or:

$$
\frac{dC_r}{C_r} = -\alpha \cdot dt
$$

or:

$$
\ln C_r = -\alpha t + \beta_c
$$

The general solution of eqn. 51c is:

$$
\ln C_r = -\alpha t + \beta_c
$$

where: $\beta_c$ is the integration constant.

Using $C_r = C_1$, $C_r = C_2$, and $C_r = C_m$ when $t = t_1$, $t = t_2$, and $t_m = \frac{1}{2} (t_1 + t_2)$ (i.e. the mid time) respectively, one finds from eqn. 53a:

$$
\ln C_1 = -\alpha t_1 + \beta_c \quad \text{or:} \quad t_1 = (\beta_c - \ln C_1) / \alpha
$$

$$
\ln C_2 = -\alpha t_2 + \beta_c \quad \text{or:} \quad t_2 = (\beta_c - \ln C_2) / \alpha
$$

$$
\ln C_m = -\alpha t_m + \beta_c \quad \text{or:} \quad t_m = (\beta_c - \ln C_m) / \alpha
$$

Using again $t_m = (t_1 + t_2) / 2$ one gets from eqn. 53b and c:

$$
t_m = \frac{\beta_c - \ln C_1 + \beta_c - \ln C_2}{2\alpha} = \frac{\beta_c - \frac{1}{2} \ln(C_1C_2)}{\alpha}
$$

Comparing eqn. 54 with eqn. 53d one can see that:

$$
\ln C_m = \frac{1}{2} \ln(C_1C_2)
$$

or:

$$
C_m = (C_1C_2)^{0.5} = C_1C_2
$$

Eqn. 55b shows that the time averaged salinity $C_m$ can be taken as the logarithmic (or geometric) mean of the initial ($C_1$) and final ($C_2$) salinity (fig. 6).

Saltmod uses the geometric mean to calculate the leaching. Since the amount of salt removed depends on $C_m$, which depends on $C_1$ and $C_2$, and since $C_2$ again depends on the amount of salt removed, a trial and error procedure is required to find the correct balance.
4.3 Salt balances under full crop rotation

In the salt balances under full crop rotation (Kr=4), all hydrological and salinity values of the different land use types are pooled (fig. 7)

4.3.1 Rootzone

The salt balance of the rootzone made on the basis of the topsoil waterbalance (eqn. 12):

$$\Delta Z_{r4} = P_p C_p + (l_g - l_d) C_i - S_o(0.1 C_{r4i} + C_l) + R_f C_{ksi} - L_f C_{L4}$$  \hspace{1cm} (56)

where: $\Delta Z_{r4}$ is salt storage in the rootzone when $Kr = 4$ (dS/season), $C_p$ is the salt concentration of the rain water (dS/m), $C_i$ is the salt concentration of the surface irrigation water including the use of drain or well water for irrigation (dS/m), $C_{r4i}$ is the salt concentration of the soil moisture in the rootzone at the start of the season when saturated, equal to the salt concentration of the same at the end of the previous season (dS/m), $C_{ksi}$ is the salt concentration of the capillary rise based on soil salinity in the transition zone, when saturated, at the end of the previous season and depending on the presence or absence of a subsurface drainage system as defined in eqn. 57a, b (dS/m), and $C_{L4}$ (see eqn. 60) is the seasonal average salt concentration of the percolation water (dS/m).

When a subsurface drainage is present we find:

$$C_{ksi} = C_{ksi}$$  \hspace{1cm} (57a)

otherwise:

$$C_{ksi} = C_{xi}$$  \hspace{1cm} (57b)

where: $C_i$ is the salt concentration of the water in the transition zone, when saturated, at the end of the previous season (EC in dS/m), $C_{ksi}$ is the salt concentration of the water in the part of the transition zone which is above drain level, when saturated (EC in dS/m).

Figure 7. Pooled hydrological factors in areas under full crop rotation ($Kr = 4$)
The concentration $C_p$ can usually be taken equal to zero, but in coastal areas it may reach a positive value that is assumed to be known.

### 4.3.1.1 Salt concentration of the irrigation water

The salt concentration $C_i$ of the irrigation water depends on the use of groundwater for irrigation:

$$C_i = (lC_{ic} + D_d C_{di} + F_w G_w C_{qi}) / (l + D_d + F_w G_w) \quad (58)$$

where: $C_{ic}$ is the known seasonal average salt concentration of the inflowing canal water (dS/m), $C_{di}$ is the salt concentration of the drainage water at the end of the previous season (dS/m), $C_{qi}$ is the salt concentration of the water in the aquifer, when saturated, at the end of the previous season (dS/m).

### 4.3.1.2 Initial salt concentration of the drainage water

The calculation of the salt concentration $C_{di}$ is based on eqn. 31 and found from:

$$C_{di} = F_{ix}(G_{dbi} C_{xbi} + G_{dai} C_{xai}) / G_d \quad (59)$$

where: $F_{ix}$ is the leaching efficiency of the transition zone (–), $C_{xbi}$ is the salt concentration of the soil moisture in the part of the transition zone below drain level, when saturated, at the end of the previous season (dS/m), $C_{xai}$ is the salt concentration of the soil moisture in the part of the transition zone above drain level, when saturated, at the end of the previous season (dS/m).

### 4.3.1.3 Seasonal average salt concentration of the percolation water

The seasonal average salt concentration $C_{L4}$ of the percolation water is found from:

$$C_{L4} = F_{ir} C_{r4V} \quad (60)$$

where: $C_{r4V}$ is the seasonal average salt concentration of the soil moisture in the rootzone when saturated (dS/m), and $F_{ir}$ is the leaching efficiency of the rootzone (–). The average $C_{r4V}$ is calculated from:

$$C_{r4V} = (C_{r4i} C_{r4f})^{1/2} \quad [C_{r4f} \leq C_{r4i}] \quad (61a)$$

$$C_{r4V} = (C_{r4i} + C_{r4f})/2 \quad [C_{r4f} > C_{r4i}] \quad (61b)$$

where: $C_{r4i}$ is the final salt concentration of the soil moisture in the rootzone when saturated (dS/m), at the end of the present season (dS/m).

### 4.3.1.4 Final salt concentration in the rootzone

The final salt concentration of the soil moisture in the rootzone, when saturated, is calculated as:

$$C_{r4f} = C_{r4i} + \Delta Z_{r4} / P_r D_r \quad (62)$$

Since the salt storage, or change in salt content, $\Delta Z_{r4}$ depends on the salt concentration of the percolation water $C_{L4}$, which again depends on the final salt concentration $C_{r4f}$, a trial and error calculation procedure is required to strike the correct balance for the calculation of $C_{r4f}$ in eqn. 62.
4.3.2 Transition zone

The salt balance of the transition zone depends on the absence or presence of a subsurface drainage system.

4.3.2.1 Absence of a subsurface drainage system

In the absence of a subsurface drainage system, the salt balance of the transition zone is based on the water balance of the same (eqn. 4):

\[ L_r C_L + L_c C_{ic} + V_r C_{qi} = R_r C_{xv} + F_{ix} V_L C_{xv} + \Delta Z_x \]  

(63)

where: \( C_{qi} \) is the salt concentration of the water in the aquifer, when saturated, of the previous season (EC in dS/m), \( C_{xv} \) (eqn. 64a,b) is the seasonal average salt concentration of the water in the transition zone, when saturated (EC in dS/m), and \( \Delta Z_x \) is the storage of salt in the transition zone.

4.3.2.2 Presence of a subsurface drainage system

When a subsurface drainage system is present, the steady state water balance of the transition zone (eqn. 4) is split into a balance of the upper part, above drain level, and a lower part, below drain level. For the upper part we have:

\[ L_r + L_c + V_r - V_L - G_b = R_r + G_a \]  

(64a)

and for the lower part:

\[ L_r + L_c - R_r - G_a + V_r = V_L + G_b \]  

(64b)

Hence, the salt balance of the upper part becomes:

\[ \Delta Z_{xa} = L_r C_L + L_c C_{ic} + (V_r - V_L - G_b) F_{ix} C_{xbi} - R_r C_{xv} - F_{ix} G_a C_{xav} \]  

(65)

where: \( \Delta Z_{xa} \) is the salt storage in the part of the transition zone above drain level (dS/season), \( C_{xav} \) is the seasonal average salt concentration of the water in the part of the transition zone, when saturated, above the drain level (EC in dS/m), and \( C_{xbi} \) is the salt concentration of the water in the part of the transition zone below drain level, when saturated, at the end of the previous season (EC in dS/m).

The salt balance of the lower part becomes:

\[ \Delta Z_{xb} = F_{ix} (L_r + L_c - R_r - G_a) C_{xav} + V_r C_{qi} - F_{ix} (V_L + G_b) C_{xbv} \]  

(66)

where: \( \Delta Z_{xb} \) is the salt storage in the part of the transition zone above drain level (dS/season), \( C_{xbv} \) is the seasonal average salt concentration of the water in the part of the transition zone, below the drain level (EC in dS/m).

4.3.2.3 Seasonal average salt concentration of the water in the transition zone

In the absence of a subsurface drainage system, the seasonal average salt concentration \( C_{xv} \) of the transition zone, when saturated, is found from:
where: $C_{gi}$ is the salt concentration of the soil moisture in the transition zone, when saturated, at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m), $C_{gf}$ is the final salt concentration of the soil moisture in the transition zone, when saturated, at the end of the season (dS/m).

In the presence of a subsurface drainage system, the seasonal average salt concentration $C_{ga}$ of the upper part of the transition zone, when saturated, above the level of the watertable, is found from:

\[
C_{ga} = (C_{gap}C_{apl})^{1/2} \quad [C_{gap} \leq C_{apl}] \\
C_{ga} = (C_{gap} + C_{apl})/2 \quad [C_{gap} > C_{apl}]
\]

where: $C_{gap}$ is the salt concentration of the soil moisture in the transition zone, when saturated, above drain level at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m), $C_{apl}$ is the salt concentration of the same at the end of the season (dS/m).

In the presence of a subsurface drainage system, the seasonal average salt concentration $C_{gb}$ of the lower part of the transition zone, when saturated, below the level of the watertable, is found from:

\[
C_{gb} = (C_{gap}C_{apl})^{1/2} \quad [C_{gap} \leq C_{apl}] \\
C_{gb} = (C_{gap} + C_{apl})/2 \quad [C_{gap} > C_{apl}]
\]

where: $C_{gap}$ is the salt concentration of the soil moisture in the transition zone, when saturated, above drain level at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m), $C_{apl}$ is the salt concentration of the same at the end of the season (dS/m).

4.3.2.4 Final salt concentration in the transition zone

In the absence of a subsurface drainage system, the final salt concentration of the soil moisture in the transition zone, when saturated, is calculated as:

\[
C_{xf} = C_{xi} + \Delta Z_x / P_{ix}D_x
\]

Since the salt storage, or change in salt content, $Z_x$, depends on the salt concentration of the water draining vertically downward to the aquifer, which again depends on the final salt concentration $C_{xf}$, a trial and error calculation procedure is required to strike the correct balance.

In the presence a subsurface drainage system, the final salt concentration of the soil moisture in the upper part of the transition zone, when saturated, above drain level, is calculated as:

\[
C_{xaf} = C_{xai} + \Delta Z_{xa} / [P_{ix}(D_{i}-D_{l})]
\]

Since the salt storage, or change in salt content, $Z_{xa}$, depends on the salt concentration of the drainage water, which again depends on the final salt concentration $C_{xaf}$, a trial and error calculation procedure is required to strike the correct balance.

In the presence a subsurface drainage system, the final salt concentration of the soil moisture
in the lower part of the transition zone, when saturated, below drain level, is calculated as:

\[ C_{xbf} = C_{xbi} + \Delta Z_{xb} / \{P_{lx}(D_r + D_x - D_d)\} \]  

(71b)

Since the salt storage, or change in salt content, \( Z_{xb} \), depends on the salt concentration of the drainage water, which again depends on the final salt concentration \( C_{xbf} \), a trial and error calculation procedure is required to strike the correct balance.

### 4.3.3 Aquifer

The salt balance of the aquifer zone is based on the water balance of the same (eqn. 5):

\[ \Delta Z_{q} = G_x C_{x} + V_{x} C_{xx} - (G_{o} + V_{r} + G_{w}) C_{ov} \]  

(72)

where: \( C_{x} \) is the salt concentration of the horizontally inflowing groundwater (dS/m), \( C_{ov} \) is the seasonal average salt concentration of the horizontally outflowing groundwater (dS/m), and \( C_{xx} \) is the salt concentration of the water in the transition zone, depending on the absence or presence of a subsurface drainage system (dS/m):

\[ C_{xx} = C_{xv} \]  

[\( K_d = 0 \)]  

(73a)

\[ C_{xx} = C_{xbv} \]  

[\( K_d = 1 \)]  

(73b)

The final salt concentration of the soil moisture in the aquifer, when saturated, is calculated as:

\[ C_{qf} = C_{qi} + \Delta Z_{q} / P_{qq} D_{q} \]  

(74)

Since the salt storage, or change in salt content, \( \Delta Z_{q} \), depends on the seasonal average salt concentration of the water draining horizontally out of the aquifer \( C_{ov} \), which again depends on the final salt concentration \( C_{qf} \), a trial and error calculation procedure is required to strike the correct balance.

### 4.3.4 Salt concentration of drain and well water

The seasonal average salt concentration \( C_{d} \) (EC in dS/m) of the subsurface drainage water is calculated on the basis of eqn. 31 as a weighted average of the seasonal average salt concentrations of the flows entering the drain from above and below drain level:

\[ C_{d} = F_{lx}(G_{o} C_{xav} + G_{xbv}) / G_{d} \]  

(75)

The seasonal average salt concentration \( C_{w} \) of the pumped well water is found from:

\[ C_{w} = F_{lx} C_{qv} \]  

(76)

### 4.4 Salt balances under zero crop rotation

In the salt balances under zero crop rotation (\( K_r = 0 \)), all hydrological and salinity values for the root zones of the different land use types are separated, but in the transition zone they are pooled (fig. 8).
4.4.1 Rootzone

The salt balance of the rootzone (eqn. 56) is split into 3 parts:

\[
\Delta Z_{0A} = P_p C_p + I_{0A} C_i + R_{0A} C_{xki} - S_{0A} (0.1 C_{10A} + C_i) - L_{0A} C_{LOA} \tag{77a}
\]

\[
\Delta Z_{0B} = P_p C_p + I_{0B} C_i + R_{0B} C_{xki} - S_{0B} (0.1 C_{10B} + C_i) - L_{0B} C_{LOB} \tag{77b}
\]

\[
\Delta Z_{0U} = P_p C_p + S_{0U} C_i + R_{0U} C_{xki} - S_{0U} (0.1 C_{10U} + C_i) - L_{0U} C_{LOU} \tag{77c}
\]

where: \( \Delta Z_{0A} \) is the salt storage in the rootzone of the irrigated group A crop(s) when \( K_r = 0 \) (dS/season), \( \Delta Z_{0B} \) is the salt storage in the rootzone of the irrigated group B crop(s) when \( K_r = 0 \) (dS per season), \( \Delta Z_{0U} \) is the salt storage in the rootzone of the non-irrigated land when \( K_r = 0 \) (dS/season), \( C_{0Ai} \) is the salt concentration of the soil moisture in the rootzone, when saturated, of the group A crop(s), at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m), \( C_{0Bi} \) is the salt concentration of the soil moisture in the rootzone, when saturated, of the group B crop(s), at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m), \( C_{0Ui} \) is the salt concentration of the soil moisture in the rootzone, when saturated, of the non-irrigated land at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m), \( C_{LOA} \) is the seasonal average salt concentration of the percolation water from the irrigated group A crop(s) (dS/m), \( C_{LOB} \) is the seasonal average salt concentration of the percolation water from the irrigated group B crop(s) (dS/m), and \( C_{LOU} \) is the seasonal average salt concentration of the percolation water from the non-irrigated land (dS/m).

In the above equations it can be seen that the salt concentration of the surface drainage \( S_0 \) is assumed to be equal to the concentration \( C_i \) of the irrigation water plus 10% of the salt concentration of the rootzone \( C_i \). Hence, the leaching efficiency of the surface drainage water is tentatively set at a low value 0.1. In a future version of Saltmod, this value may be made variable.

![Figure 8](image-url). Separated hydrological factors in the rootzone under zero crop rotation (\( K_r = 0 \)), pooling of factors in the transition zone.
The seasonal average salt concentrations $C_{LOA}$, $C_{LOB}$, and $C_{LOU}$ of the percolation water are found from:

$$C_{LOA} = F_{ir}C_{r0Av} \quad (78a)$$

$$C_{LOB} = F_{ir}C_{r0Bv} \quad (78b)$$

$$C_{LOU} = F_{ir}C_{r0Uv} \quad (78c)$$

where: $C_{r0Av}$ is the seasonal average salt concentration of the soil moisture in the rootzone, when saturated, of the group A crop(s) when $K_i = 0$ (dS/m), $C_{r0Bv}$ is the seasonal average salt concentration of the soil moisture in the rootzone, when saturated, of the group B crop(s) when $K_i = 0$ (dS/m), and $C_{r0Uv}$ is the seasonal average salt concentration of the soil moisture in the rootzone, when saturated, of the non-irrigated land when $K_i = 0$ (dS/m). They are calculated from the following six equations depending on whether the salinity is decreasing or increasing:

$$C_{r0Av} = (C_{0rAI} - C_{0rAf})^{1/2} \quad [C_{0rAI} \leq C_{0rAf}] \quad (79a)$$

$$C_{r0Av} = (C_{0rAI} + C_{0rAf}) / 2 \quad [C_{0rAf} > C_{0rAI}] \quad (79b)$$

$$C_{r0Av} = (C_{0rAI} - C_{0rAf})^{1/2} \quad [C_{0rAI} \leq C_{0rAf}] \quad (79c)$$

$$C_{r0Av} = (C_{0rAI} + C_{0rAf}) / 2 \quad [C_{0rAf} > C_{0rAI}] \quad (79d)$$

$$C_{r0Av} = (C_{0rAI} - C_{0rAf})^{1/2} \quad [C_{0rAI} \leq C_{0rAf}] \quad (79e)$$

$$C_{r0Av} = (C_{0rAl} + C_{0rAl}) / 2 \quad [C_{0rAF} > C_{0rAI}] \quad (79f)$$

where: $C_{0rAI}$ is the final salt concentration of the soil moisture in the rootzone, when saturated, of the group A crop(s) at the end of the present season (dS/m), $C_{0rBf}$ is the final salt concentration of the soil moisture in the rootzone, when saturated, of the non-irrigated land at the end of the present season (dS/m), $C_{r0Uf}$ is the final salt concentration of the soil moisture in the rootzone, when saturated, of the non-irrigated land at the end of the present season (dS/m).

The final salt concentrations of the soil moisture in the rootzone are calculated as:

$$C_{r0AI} = C_{0rAI} + \Delta Z_{r0A}/P_r D_r \quad (80a)$$

$$C_{r0BI} = C_{0rBI} + \Delta Z_{r0B}/P_r D_r \quad (80b)$$

$$C_{r0Uf} = C_{0rUf} + \Delta Z_{r0U}/P_r D_r \quad (80c)$$

Since the salt storage, or change in salt content depends on the salt concentration of the percolation water, which again depends on the final salt concentration, a trial and error calculation procedure is required to strike the correct balance for the calculation of the final salt concentrations in eqns. 80a, b and c.

4.4.2 Transition zone

The seasonal average salt concentration $C_{LO}$ of the percolation water into the transition zone is calcu-
lated as the weighted average of the salt concentrations of the percolation water from the A, B, and U areas:

\[ C_{L0} = \frac{(L_A C_{0A} + L_B C_{0B} + L_U C_{0U})}{(L_A + L_B + L_U)} \]  

(81)

The other salt balances of the transition zone are calculated with the equations of section 4.3.2, \( C_{L0} \) replacing \( C_{L4} \).

### 4.5 Salt balances under intermediate crop rotations

#### 4.5.1 Types of crop rotation

Saltmod offers the following three intermediate crop rotation types:

1. A part or all of the non-irrigated land is permanently used unchanged such throughout the seasons (e.g. permanently uncultivated land, non-irrigated grazing land, non irrigated agro-forestry, abandoned land). The rotation key \( K_r \) is set equal to 1.

2. A part or all of the land under group A crop(s) is permanently used unchanged such throughout the seasons (e.g. the land under irrigated sugarcane, double irrigated rice cropping). The rotation key \( K_r \) is set equal to 2.

3. A part or all of the land under group B crop(s) is permanently used unchanged such throughout the seasons (e.g. the land under irrigated orchards). The rotation key \( K_r \) is set equal to 3.

It is immaterial whether one assigns a permanent land use type either to the A or B group of crop(s). Also, a group of crops may consist of only one type of crop. It would be good practice to reserve one group for the intensively irrigated crops and the other for the more lightly irrigated crops.

The Saltmod program calculates the minimum seasonal area fraction of the land use land use fractions \( A, B \) and \( U \). These minima are called \( A_c, B_c \) and \( U_c \) respectively. Depending on the value of \( K_r \), we have the following situations:

1. \( K_r = 1 \). The fraction \( U_c \) is used as the permanently non-irrigated land, throughout the seasons, and the fraction \( 1 - U_c \) is the land with fully rotational land use of irrigated A and/or B type crops and/or non-irrigated land.

2. \( K_r = 2 \). The fraction \( A_c \) is used as the permanently irrigated land under group A crop(s), throughout the seasons, and the fraction \( 1 - A_c \) is the land with fully rotational land use of irrigated A and/or B type crops and/or non-irrigated land.

3. \( K_r = 3 \). The fraction \( B_c \) is used as the permanently irrigated land under group B crop(s), throughout the seasons, and the fraction \( 1 - B_c \) is the land with fully rotational land use of irrigated A and/or B type crops and/or non-irrigated land.

#### 4.5.2 Part of the area permanently non-irrigated, \( K_r = 1 \)

##### 4.5.2.1 Rootzone

The salt balance of the rootzone (eqn. 56) is split into 2 parts, one separate part for the permanently non-irrigated area \( U_c \) and one pooled part for the remaining area \( 1 - U_c = U^* \) with full crop rotation (fig. 9). The balance reads:
\[ \Delta Z_{1U} = P_p C_p + S_{0U} C_i + R_{RU} C_{xii} - S_{0U} (0.1 C_{11U} + C_i) - L_{0U} C_{11U} \]  

(82a)

\[ \Delta Z_{1*} = P_p C_p + (\Omega_{1A} S_{0A} + \Omega_{1B} S_{0B} + \Omega_{1U} S_{0U}) C_i + (\Omega_{1A} R_{RA} + \Omega_{1B} R_{RB} + \Omega_{1U} R_{RU}) C_{xii} \]

\[ \quad - (\Omega_{1A} S_{0A} + \Omega_{1B} S_{0B} + \Omega_{1U} S_{0U}) (0.1 C_{11*} + C_i) \]

\[ \quad - (\Omega_{1A} L_{rA} + \Omega_{1B} L_{rB} + \Omega_{1U} L_{rU}) C_{11*} \]  

(82b)

where: \( \Delta Z_{1U} \) is the salt storage in the rootzone of the permanently non-irrigated land, throughout the seasons, when \( K_r = 1 \) (dS/season), \( \Delta Z_{1*} \) is the salt storage in the rootzone of the land outside the permanently non-irrigated area, when \( K_r = 1 \) (dS/season), \( C_{11U} \) is the salt concentration of the soil moisture in the rootzone, when saturated, at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m), \( C_{11*} \) is the salt concentration of the soil moisture in the rootzone, when saturated, of the land outside the permanently non-irrigated area, at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m), \( C_{11U} \) is the seasonal average salt concentration of the percolation water from the permanently non-irrigated land (dS/m), \( C_{11*} \) is the seasonal average salt concentration of the percolation water from the land outside the permanently non-irrigated area (dS/m). \( \Omega_{1U}, \Omega_{1A} \) and \( \Omega_{1B} \) are area weight factors defined as follows:

\[ \Omega_{1U} = (U - U_C) / (1 - U_C) \]  

(83a)

\[ \Omega_{1A} = A(1 - U_C) \]  

(83b)

\[ \Omega_{1B} = B(1 - U_C) \]  

(83c)

The seasonal average salt concentrations \( C_{11U} \) and \( C_{11*} \) of the percolation water are found from:

\[ C_{11U} = F_ru C_{11UV} \]  

(84a)

\[ C_{11*} = F_{ru} C_{11*V} \]  

(84b)

---

Figure 9. Separate hydrological factors in the rootzone of the permanently non-irrigated land \((U_C)\) and pooled factors in the remaining rotational land \((U^*)\)
where: \( C_{1,U} \) is the seasonal average salt concentration of the soil moisture in the rootzone, when saturated, of the permanently non-irrigated land, when \( K_r = 1 \) (dS/m), \( C_{1,V} \) is the seasonal average salt concentration of the soil moisture in the rootzone, when saturated, of the land outside the permanently non-irrigated area, when \( K_r = 1 \) (dS/m). They are calculated from the following four equations depending on whether the salinity is decreasing or increasing:

\[
\begin{align*}
C_{1,U} &= (C_{1,U}C_{1,U})^{1/2} & [C_{1,U} \leq C_{1,U}] \\
C_{1,U} &= (C_{1,U} + C_{1,U}) / 2 & [C_{1,U} > C_{1,U}] \\
C_{1,V} &= (C_{1,V}C_{1,V})^{1/2} & [C_{1,V} \leq C_{1,V}] \\
C_{1,V} &= (C_{1,V} + C_{1,V}) / 2 & [C_{1,V} > C_{1,V}]
\end{align*}
\]  

(85a)  
(85b)  
(85c)  
(85d)

where: \( C_{1,U} \) is the final salt concentration of the same at the end of the present season (dS/m), \( C_{1,V} \) is the final salt concentration of the same at the end of the present season (dS/m).

The final salt concentrations of the soil moisture in the rootzone are calculated as:

\[
\begin{align*}
C_{1,U} &= C_{1,U} + \Delta Z_{1,U} / P_t D_t & (86a) \\
C_{1,V} &= C_{1,V} + \Delta Z_{1,V} / P_t D_t & (86b)
\end{align*}
\]

Since the salt storage, or change in salt content depends on the salt concentration of the percolation water, which again depends on the final salt concentration, a trial and error calculation procedure is required to strike the correct balance for the calculation of the final salt concentrations in eqn. 86a and b.

4.5.2.2 Transition zone

The seasonal average salt concentration \( C_{L1} \) of the percolation water \( L_r \) from the rootzone into the transition zone is calculated as the weighted average of the salt concentrations of the percolation water from the \( U_c \) and \( U^* = 1 - U_c \) areas.

The percolation \( L_{U^*} \) in the \( U^* \) area, i.e. outside the permanently non-irrigated land, expressed in m³/season per m² outside area, is found from:

\[
L_{U^*} = \Omega_{1,ULU} + \Omega_{1,AL,A} + \Omega_{1,BL,B}
\]

(87)

and the salt concentration \( C_{L1} \) from:

\[
C_{L1} = [L_{U}C_{1,AU}U_c + L_{U^*}C_{1,V}(1 - U_c)] / L_r
\]

(88)

The other salt balances of the transition zone are calculated using the equations of section 4.3.2, \( C_{L1} \) replacing \( C_{L4} \).

4.5.3 Part of the irrigated area permanently under group A crop(s), \( K_r = 2 \)

4.5.3.1 Rootzone

When \( K_r = 2 \), the salt balance of the rootzone (eqn. 56) is split into 2 parts in a similar way as described
in section 4.5.2 (fig. 8) for \( K_r = 1 \). One part represents the permanently irrigated area \( A_c \) under group A crop(s), and one part the remaining area \( 1 - A_c = A^* \) with full crop rotation. The two salt balances of the rootzone thus read:

\[
\Delta Z_{2A} = P_p C_p + I_{\Delta A} C_i + R_i A C_{\text{ski}} - S_{\Delta A}(0.1 C_{2A} + C_i) - L_i A C_{L2A}
\]

\[
\Delta Z_{2*} = P_p C_p + (\Omega_{2A} I_{\Delta A} + \Omega_{2B} L_{\Delta B} + \Omega_{2U} S_{\Delta U}) C_i + (\Omega_{2A} R_i A + \Omega_{2B} R_i B + \Omega_{2U} R_i U) C_{\text{ski}}
\]

\[
- (\Omega_{2A} S_{\Delta A} + \Omega_{2B} S_{\Delta B} + \Omega_{2U} S_{\Delta U})(0.1 C_{2*} + C_i)
\]

\[
- (\Omega_{2A} L_{\Delta A} + \Omega_{2B} L_{\Delta B} + \Omega_{2U} L_{\Delta U}) C_{L2*}
\]

where: \( \Delta Z_{2A} \) is the salt storage in the rootzone of the permanently irrigated land under group A crop(s), throughout the seasons, when \( K_r = 2 \) (dS/season), \( \Delta Z_{2*} \) is the salt storage in the rootzone of the land outside the permanently irrigated area under group A crop(s), when \( K_r = 2 \) (dS/season), \( C_{2A} \) is the salt concentration of the soil moisture in the rootzone, when saturated, in the permanently irrigated land under group A crop(s), at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m), \( C_{2*} \) is the salt concentration of the soil moisture in the rootzone, when saturated, of the land outside the permanently irrigated land under group A crop(s) at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m), \( C_{L2A} \) is the seasonal average salt concentration of the percolation water from the permanently irrigated land under group A crop(s), throughout the seasons (dS/m), \( C_{L2*} \) is the seasonal average salt concentration of the percolation water from the land outside the permanently irrigated area under group A crops (dS/m). \( \Omega_{2U}, \Omega_{2A} \) and \( \Omega_{2B} \) are area weight factors defined as follows:

\[
\Omega_{2A} = (A - A_c) / (1 - A_c)
\]

\[
\Omega_{2B} = B / (1 - A_c)
\]

\[
\Omega_{2U} = U / (1 - A_c)
\]

The seasonal average salt concentrations \( C_{L2A} \) and \( C_{L2*} \) of the percolation water are found from:

\[
C_{L2A} = F_i C_{2A}
\]

\[
C_{L2*} = F_i C_{2*}
\]

where: \( C_{2A} \) is the seasonal average salt concentration of the soil moisture in the rootzone, when saturated, of the permanently irrigated land under group A crop(s), when \( K_r = 2 \) (dS/m), \( C_{2*} \) is the seasonal average salt concentration of the soil moisture in the rootzone, when saturated, of the land outside the permanently irrigated land under group A crop(s), when \( K_r = 2 \) (dS/m). They are calculated from:

\[
C_{2AV} = (C_{2A} + C_{2AV})^{1/2}
\]

\[
C_{2AV} = (C_{2AV} + C_{2AV}) / 2
\]

\[
C_{2*V} = (C_{2*} + C_{2*V})^{1/2}
\]

\[
C_{2*V} = (C_{2*} + C_{2*V}) / 2
\]
where: $C_{2AL}$ is the final salt concentration of the same at the end of the present season (dS/m), $C_{2'T}$ is
the final salt concentration of the same at the end of the present season (dS/m).

The final salt concentrations of the soil moisture in the rootzone are calculated as:

$$C_{2AL} = C_{2AL} + \frac{\Delta Z_{2'A}}{P_{trD_r}} \quad (93a)$$

$$C_{2'T} = C_{2'T} + \frac{\Delta Z_{2'T}}{P_{trD_r}} \quad (93b)$$

Since the salt storage, or change in salt content depends on the salt concentration of the percolation
water, which again depends on the final salt concentration, a trial and error calculation procedure is
required to strike the correct balance for the calculation of the final salt concentrations in eqns. 93a
and b.

4.5.3.2 Transition zone

The seasonal average salt concentration $C_{L2}$ of the percolation water $L_r$ from the rootzone into the
transition zone is calculated as the weighted average of the salt concentrations of the percolation water
from the $A_c$ and $A' = 1 - A_c$ areas.

The percolation $L_{rA'}$ in the $A'$ area, i.e. outside the permanently irrigated land under group A
crop(s), expressed in m$^3$/season per m$^2$ outside area, is found from:

$$L_{rA'} = \Omega_{2A}L_{rA} + \Omega_{2B}L_{rB} + \Omega_{2U}L_{rit} \quad (94)$$

and the salt concentration $C_{L2}$ from:

$$C_{L2} = \frac{L_{rA}C_{2AV}A_c + L_{rA'}C_{2AV'}(1 - A_c)}{L_r} \quad (95)$$

The other salt balances of the transition zone are calculated using the equations of section 4.3.2 with
$C_{L4}$ replaced by $C_{L2}$.

4.5.4 Part of the irrigated area permanently under group B crop(s), $K_r = 3$

4.5.4.1 Rootzone

When $K_r = 3$, the salt balance of the rootzone (eqn. 56) is split into 2 parts in a similar way as described
in section 4.5.2 for $K_r = 1$. One part represents the permanently irrigated area $B_c$ under group B crop(s),
and one part the remaining area $1 - B_c = B'$ with full crop rotation. The two salt balances of the root-
zone thus read:

$$\Delta Z_{3B} = P_1p_{C_p} + l_{AB}C_{1} + R_{IB}C_{xiv} - S_{gb}(0.1C_{2Bi} + C_{1}) - L_{rB}C_{L3B} \quad (96a)$$

$$\Delta Z_{3'} = P_1p_{C_p} + (\Omega_{3A}l_{AB} + \Omega_{3B}l_{AB} + \Omega_{3U}S_{i})C_{1} + (\Omega_{3A}R_{A} + \Omega_{3B}R_{B} + \Omega_{3U}R_{U})C_{xiv}$$

$$- (\Omega_{3A}S_{2A} + \Omega_{3B}S_{2B} + \Omega_{3U}S_{2U}) (0.1C_{31} + C_{1})$$

$$- (\Omega_{3A}L_{rA} + \Omega_{3B}L_{rB} + \Omega_{3U}L_{rU}) C_{L3'} \quad (96b)$$

where: $\Delta Z_{3B}$ is the salt storage in the rootzone of the perma nently irrigated land under group B
crop(s), throughout the seasons, when $K_r$=2 (dS/season), $\Delta Z_{3'}$ is the salt storage in the rootzone of
the land outside the permanently irrigated area under group B crop(s), when \( K_r = 2 \) (dS/season), \( C_{3B} \) is the salt concentration of the soil moisture in the rootzone, when saturated, in the permanently irrigated land under group B crop(s), at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m). \( C_{2B} \) is the salt concentration of the soil moisture in the rootzone, when saturated, of the land outside the permanently irrigated land under group B crop(s) at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m). \( C_{3B} \) is the seasonal average salt concentration of the percolation water from the permanently irrigated land under group B crop(s), throughout the seasons (dS/m). \( C_{3'} \) is the seasonal average salt concentration of the percolation water from the land outside the permanently irrigated area under group B crops (dS/m). \( \Omega_{B3} \), \( \Omega_{A3} \) and \( \Omega_{U3} \) are area weight factors defined as follows:

\[
\begin{align*}
\Omega_{3B} &= \frac{(B - B_c)}{(1 - B_c)} \\
\Omega_{3A} &= \frac{A}{(1 - B_c)} \\
\Omega_{3U} &= \frac{U}{(1 - B_c)}
\end{align*}
\]

(97a) (97b) (97c)

The seasonal average salt concentrations \( C_{3B} \) and \( C_{3'} \) of the percolation water are found from:

\[
\begin{align*}
C_{3B} &= F_r C_{3Bv} \\
C_{3'} &= F_r C_{3'v}
\end{align*}
\]

(98a) (98b)

where: \( C_{3Bv} \) is the seasonal average salt concentration of the soil moisture in the rootzone, when saturated, of the permanently irrigated land under group B crop(s), when \( K_r = 3 \) (dS/m), \( C_{3'v} \) is the seasonal average salt concentration of the soil moisture in the rootzone, when saturated, of the land outside the permanently irrigated land under group B crop(s), when \( K_r = 3 \) (dS/m). They are calculated from:

\[
\begin{align*}
C_{3Bv} &= (C_{3Bi} C_{3Bi})^{1/2} \quad [C_{3Bi} \leq C_{3Bi}] \\
C_{3Bv} &= (C_{3Bi} + C_{3Bi}) / 2 \quad [C_{3Bi} > C_{3Bi}] \\
C_{3'v} &= (C_{3'i} C_{3'i})^{1/2} \quad [C_{3'i} \leq C_{3'i}] \\
C_{3'v} &= (C_{3'i} + C_{3'i}) / 2 \quad [C_{3'i} > C_{3'i}]
\end{align*}
\]

(99a) (99b) (99c) (99d)

where: \( C_{3Bi} \) is the salt concentration of the soil moisture in the rootzone, when saturated, in the permanently irrigated area under group B crop(s) land, when \( K_r = 3 \), at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m), \( C_{3Bi} \) is the final salt concentration of the same at the end of the present season (dS/m), \( C_{3'i} \) is the salt concentration of the soil moisture in the rootzone, when saturated, of the land outside the permanently irrigated land under group B crop(s), when \( K_r = 3 \), at the start of the season, equal to the salt concentration of the same at the end of the previous season (dS/m), \( C_{3'i} \) is the final salt concentration of the same at the end of the present season (dS/m).

The final salt concentrations of the soil moisture in the rootzone are calculated as:

\[
\begin{align*}
C_{3Bi} &= C_{3Bi} + \Delta Z_{3B} / P_i D_r \\
C_{3'i} &= C_{3'i} + \Delta Z_{3'} / P_i D_r
\end{align*}
\]

(100a) (100b)
Since the salt storage, or change in salt content depends on the salt concentration of the percolation water, which again depends on the final salt concentration, a trial and error calculation procedure is required to strike the correct balance for the calculation of the final salt concentrations in eqns. 100a and b.

4.5.4.2 Transition zone

The seasonal average salt concentration $C_{L3}$ of the percolation water $L_r$ from the rootzone into the transition zone is calculated as the weighted average of the salt concentrations of the percolation water from the Bc and $B^* = 1 - AB$ areas.

The percolation $L_{B^*}$ in the $B^*$ area, i.e. outside the permanently irrigated land under group B crop(s), expressed in m$^3$/season per m$^2$ outside area, is found from:

$$L_{B^*} = \Omega_{3B} L_{B} + \Omega_{3A} L_{A} + \Omega_{3U} L_{U}$$

and the salt concentration $C_{L3}$ from:

$$C_{L3} = \frac{[L_{B} C_{3B} B_c + L_{B^*} C_{B^*} (1 - B_c)]}{L_r}$$

The other salt balances of the transition zone are calculated using the equations of section 4.3.2 with $C_{4}$ replaced by $C_{3}$.

5. Area frequency distribution of salinity

The spatial variation in soil salinity under irrigated conditions is very high and the variation itself is very dynamic depending upon the agricultural, irrigation and drainage practices. The Gumbel distribution is assumed to fit the cumulative probability distribution of the root zone salinity: it is appropriately skew to the right, and it permits an easy introduction of a standard variation proportional to the mean.

The root zone salinities that are likely to occur at 20%, 40%, 60% and 80% of cumulative frequencies are computed by taking the predicted root zone salinity as the mean.

The cumulative Gumbel distribution, applied to salt concentration $C$, can be written as:

$$C = \mu - \sigma \alpha - \ln(-\ln\Phi) / \alpha$$

where: $C_{\Phi}$ is the value of $C$ at cumulative frequency $\Phi$ (dS/m), $\mu$ is the mean of $C$ values (dS/m), $\sigma$ is Euler’s constant, equal to 0.577, $\alpha$ equals $\pi/\sigma/6$, and $\sigma$ is the standard deviation of the $C$ values (dS/m). By assuming the relationship:

$$\sigma = \epsilon \cdot \mu$$

where $\epsilon$ is a constant proportional to the size of the area, eqn. 103 is converted to:

$$C = \mu \left[ 1 - 0.45 \epsilon - 0.78 \epsilon \ln(-\ln\Phi) \right]$$

In table 1 different values are given to $\epsilon$, depending on the size of the area. The relation is empirical and derived from various cases based on traditional soil sampling with an auger up to 30 cm depth. Larger size samples would give smaller $\epsilon$ values.
Table 1. Values of the proportion $\epsilon = \sigma/\mu$ in relation to size of the area (ha)

<table>
<thead>
<tr>
<th>Area lower limit</th>
<th>Area upper limit</th>
<th>$\epsilon$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>0.35</td>
</tr>
<tr>
<td>100</td>
<td>1000</td>
<td>0.41</td>
</tr>
<tr>
<td>1000</td>
<td>10000</td>
<td>0.53</td>
</tr>
<tr>
<td>10000</td>
<td>100000</td>
<td>0.67</td>
</tr>
</tbody>
</table>

The Gumbel relations used in Saltmod are arbitrary and need to be verified for a larger number of situations. However, the procedure used at least gives a reasonable indication of the possible area variations.

Fig. 10 shows an example of a Gumbel frequency distribution of soil salinity with a plot of the field data and the line used in Saltmod. The data are obtained in the traditional way from the Gohana region, Haryana, India, and refer to an area of 2000 ha. In total 400 samples were taken in groups of 4. Per group, the average value is used. The figure is therefore based on 100 data. Their mean value is $\mu = 5.1$ and the standard deviation is $\sigma = 3.5$.

In the example of fig. 10 the concurrence of the field data and the Saltmod estimates is fairly high.

Figure 10 Cumulative Gumbel frequency distribution of soil salinity observations in the Gohana area, Haryana, India, and the Saltmod prediction (data from D.P. Sharma, CSSRI, Karnal, India)
6. Farmers' responses

To simulate farmers' responses, the irrigated areas (A and B) can be gradually reduced if the watertable becomes shallow, or if the salinity of the rootzone becomes high. This is done by defining the farmers' response key $K_f = 1$ in the input data file. The responses are the following:

- a reduction of the irrigated area when the land becomes saline; this leads to an increase in the permanent fallow land, abandoned for agriculture
- a reduction of the irrigated area when irrigation water is scarce and the irrigation sufficiency low; this leads to an increase in the rotational fallow land
- a decrease of the field application of irrigation water when the watertable becomes shallow; this leads to a more efficient field irrigation, reduced percolation, a greater depth of the watertable, and higher soil salinity

When Saltmod is used with intermediate changes in the input data during the whole period of calculation, the response key is automatically set equal to zero, because it is supposed that the adjustments to simulate farmers' responses will be done by the user.

6.1 Reduction of irrigated area when salinization or irrigation deficiency occurs

When the final rootzone salinity of the irrigated area under A or B type crops is more than the initial salinity ($C_{AO}, C_{BO}$, as given with the input) and more than 5 dS/m, or when the irrigation sufficiency ($T_A, T_B$ as calculated by the program) is less than 0.8, the irrigated fractional areas A and B are reduced as follows:

\begin{align*}
A_n &= \beta_1 A_p \\
B_n &= \beta_1 B_p
\end{align*}

(106)

(107)

where: $A_n, A_p, B_n$ and $B_p$ are the A and B values of the next and the present year respectively, and the $f_{l1}$ values are given in table 2.

<table>
<thead>
<tr>
<th>Salinity</th>
<th>Sufficiency</th>
<th>$\beta_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 10</td>
<td>&lt; 0.7</td>
<td>0.90</td>
</tr>
<tr>
<td>5 - 10</td>
<td>0.7 - 0.8</td>
<td>0.95</td>
</tr>
<tr>
<td>&lt; 5</td>
<td>&gt; 0.8</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 2. Relation between reduction factor $f_{l1}$, soil salinity (dS/m) and irrigation sufficiency ($-$)

When judging the salinity limits used one may take into account that they are area averages, so that there are patches of land with a higher salinity, and that the salinity at field saturation used here is about half the salinity of the commonly used saturation extract. The increased value of the non-irrigated area fraction $U$ is:

\begin{equation}
U_n = 1 - A_n - B_n
\end{equation}

(108)
When the soil salinity is greater than 5 dS/m and the value of the rotation key $K_r$ is not equal to 1 (i.e. there is no permanently fallow land), its value is changed into 1, so that the presence of permanently fallow, abandoned, land is assured.

When the sufficiency $F_{SA}$ and/or $F_{SB}$ of field irrigation equals unity, then the bypass ($I_{on}$) of irrigation water in the canal system is increased accordingly:

$$I_{on} = I_{op} + \tau_A (A_p - A_n) I_{6A} + \tau_B (B_p - B_n) I_{6B}$$

(109)

where: $I_{on}$ and $I_{op}$ are values of $I_o$ in the next and present year respectively, and $\tau_A = 1$ when $F_{SA} = 1$, $\tau_B = 1$ when $F_{SB} = 1$, otherwise $F_{SA}$ and $F_{SB}$ are zero.

At the same time, when the sufficiency is less than one, then the amounts of field irrigation in the reduced areas are increased:

$$I_{An} = \frac{I_{Ap}}{\beta_1}$$

(110a)

$$I_{Bn} = \frac{I_{Bp}}{\beta_1}$$

(110b)

where: $I_{An}$, $I_{Ap}$, $I_{Bn}$, and $I_{Bp}$ are the amounts of field irrigation $I_{6A}$ and $I_{6B}$ in the $A$ and $B$ areas of the next and present year respectively.

Now, the adjustment of the soil salinity values of the permanently non-irrigated area $U_c$ (if $K_r = 1$), the permanently irrigated $A_c$ (if $K_r = 2$) and $B_c$ (if $K_r = 3$) areas is required respectively as follows:

$$C_{U_1n} = \frac{U_h (1 - \beta_1) C_{11h} + U_c C_{11uf}}{U_h (1 - \beta_1) + U_c}$$

(111a)

$$C_{2Ahn} = \frac{A_h (1 - \beta_1) C_{22h} + A_c C_{22al}}{A_h (1 - \beta_1) + A_c}$$

(111b)

$$C_{3Bhn} = \frac{B_h (1 - \beta_1) C_{33h} + B_c C_{33bf}}{B_h (1 - \beta_1) + B_c}$$

(111c)

where: $C_{2Ahn}$ is the adjusted final salt concentration of the soil moisture, when at field saturation, in the rootzone of the permanently irrigated land under group A crop(s), used for the start of the next year, $K_r = 2$ (EC in dS/m), $C_{3Bhn}$ is the adjusted final salt concentration of the soil moisture, when at field saturation, in the rootzone of the permanently irrigated land under group B crop(s), used for the start of the next year, $K_r = 3$ (EC in dS/m), and $C_{U_1n}$ is the adjusted final salt concentration of the soil moisture, when at field saturation, in the rootzone of the permanently non-irrigated land, used for the start of the next year, $K_r = 1$ (EC in dS/m).

As a result of the area reductions and irrigation increases, it may happen that the salinity in the irrigated areas is reduced again. If this brings the soil salinity below the initial levels, as given in the input, then the above processes are reversed (i.e. multiplication with $\beta$ becomes division and vice versa), but the irrigated areas will not become larger, and the amounts of field irrigation not smaller, than their initial values as given with the input.