



karamouz@aut.ac.ir



Kaplan (1974) .

Fontane and Labadie (1981) .

WESTEX

Nandalal and Bogardi (1995)

DYRESM

SDP



Nash

$$\bar{d} = (d_1, \dots, d_n) \quad (\quad)$$

:()

Maximize $Z = (f_1 - d_1)^{w_1} (f_2 - d_2)^{w_2} \dots (f_n - d_n)^{w_n}$ ()

Subject to: $f_i \geq d_i \quad i = 1, 2, \dots, n$ ()

$$w_i \quad n \quad i$$

¹ Stakeholders



ξ

Nash

SSGAQ

Maximize

$$\prod_m^{I2} E[(f_{r,m}(R_{m,i,j}) - d_{r,m})^{w_r} (f_{s,m}(S_{m+1,i,j}) - d_{s,m})^{w_s}] (f_{c,m}(\bar{C}_m) - d_{c,m})^{w_c}, \forall i, j \quad ()$$

Subject to:

$$\hat{S}_{m+1,i,j} = P'_m(\hat{S}_i, \hat{I}_j, m) \quad m = 1, \dots, I2, i = 1, \dots, n_i, j = 1, \dots, n_j \quad ()$$

$$E[(f_{r,m}(R_{m,i,j}) - d_{r,m})^{w_r} (f_{s,m}(\hat{S}_{m+1,i,j}) - d_{s,m})^{w_s}] = \sum_{n=1}^N \sum_{m=1}^{I2} \sum_{i=1}^{n_i} \sum_{j=1}^{n_j} (F_{n,m,i,j}) - \sum_{n=1}^{N-1} \sum_{m=1}^{I2} \sum_{i=1}^{n_i} \sum_{j=1}^{n_j} (F_{n,m,i,j}) \quad ()$$

$$F_{n,m,i,j} = (B_{m,i,j} + \sum_{l=1}^{n_j} F_{n,m-1,i,l} \times P_{j,l}) \quad ()$$

$$B_{m,i,j} = (f_{r,m}(R_{m,i,j}) - d_{r,m})^{w_r} (f_{s,m}(\hat{S}_{m+1,i,j}) - d_{s,m})^{w_s} \quad ()$$

$$R_{m,i,j} = \hat{S}_i - \hat{S}_{m+1,i,j} + \hat{I}_j - L_{m,i,j} \quad m = 1, \dots, I2, i = 1, \dots, n_i, j = 1, \dots, n_j \quad ()$$

$$R_{m,i,j} = r_{m,i,j}^1 + r_{m,i,j}^2 + \dots + r_{m,i,j}^P \quad m = 1, \dots, I2, i = 1, \dots, n_i, j = 1, \dots, n_j \quad ()$$

$$r_{m,i,j}^k = \alpha_{m,i,j}^k \cdot R_{m,i,j} \quad k = 1, \dots, P \quad m = 1, \dots, I2, i = 1, \dots, n_i, j = 1, \dots, n_j \quad ()$$

$$\sum_{k=1}^P \alpha_{m,i,j}^k = 100 \quad \forall m, i, j \quad ()$$

$$C_m = \frac{\sum_y (\sum_k r_{k,m,y} \times C_{k,m,y} / r_{m,y})}{Y} \quad m = 1, \dots, I2 \quad ()$$

$$R_{m,y} = S_{m,y} - S_{m+1,y} + I_{m,y} - L_{m,y} \quad I \leq m \leq I1, 1 \leq y \leq Y \quad ()$$

¹ Expected value

² Stochastic Sequential Genetic Algorithms considering the water Quality issues



$$\begin{aligned}
 R_{m,y} &= S_{m,y} - S_{l,y+l} + I_{m,y} - L_{m,y} \quad m = II, 1 \leq y \leq Y & () \\
 r_{k,m,y} &= \alpha_{m,i,j}^k \cdot r_{m,y} & () \\
 S_{min} &\leq S_{m,y} \leq S_{max} & () \\
 0 &\leq r_{k,m,y} \leq r_{k,max} \quad \forall k, m, y & () \\
 0 &\leq r_{m,i,j}^k \leq r_{k,max} \quad \forall k, m, y & () \\
 C_{i,m,y} &= g(\tilde{T}, \tilde{w}, \tilde{C}_{in}, \tilde{T}_{in}, \tilde{I}, \tilde{r}_k) \quad \forall m, y, k & () \\
 & & : \\
 & & : \alpha_{m,i,j}^k \\
 & & : B_{m,i,j} \\
 & & : \bar{C}_m \\
 & & : \tilde{C}_{in} \\
 & & : C_{k,m,y} \\
 & & : d_{r,m} \\
 & & : d_{s,m} \\
 & & : d_{c,m} \\
 & & : E() \\
 & & : f_{r,m}() \\
 & & : f_{s,m}()
 \end{aligned}$$



$) m$

$: f_{c,m}()$

$($

$: g()$

$: i$

$y m : I_{m,y}$

$()$

$() j : \hat{I}_j$

$() : \tilde{I}$

$: j$

$) y m : L_{m,y}$

$($

$() t : L_{m,i,j}$

$: l$

$: n_i$

$: n_j$

$: N$

$: n$

$m () : P'_m(\hat{S}_i, \hat{I}_j, m)$

j

i



v

P
 $P_{j,l}$
 $R_{m,i,j}$
 $r_{m,i,j}^k$
 $R_{m,y}$
 $r_{k,m,y}$
 $r_{k,max}$
 $R_{m,y}$
 \tilde{r}_k
 $\hat{S}_{m+1,i,j}$
 S_{min}
 S_{max}
 $S_{m,y}$
 \hat{S}_i
 \tilde{T}
 \tilde{T}_{in}
 $w_s / w_r / w_c$



λ

()

: \tilde{w}

: Y

: y

Nash

()

() ()

SDP

)

(

Kerachian and Karamouz (2004)

(SGA)

$$NG = n_i \times n_j \times m \times [(P-1)+1] = n_i \times n_j \times m \times P$$

()

¹ Sequential Genetic Algorithms



9

n_j n_i NG
 P m

HEC5-Q
 ()

$$f_{r,m}(R_m) = \begin{cases} R_m / d_m & \text{if } R_m \leq d_m \\ 1 & \text{otherwise} \end{cases} \quad ()$$

$$f_{s,m}(S_{m+1}) = \begin{cases} (S_{m+1} - 35) / (95) & \text{if } 35 \leq S_{m+1} \leq 130 \\ 1 & \text{otherwise} \end{cases} \quad ()$$

$$f_{c,m}(C_m) = \begin{cases} 0 & \text{if } \bar{C}_m > 3000 \\ 1 - \frac{\bar{C}_m - 1200}{3000 - 1200} & \text{if } 1200 \leq \bar{C}_m \leq 3000 \\ 1 & \text{if } 1100 \leq \bar{C}_m < 1200 \\ 0.9 + \left(\frac{0.1 \times \bar{C}_m}{1100} \right) & \text{if } \bar{C}_m < 1100 \end{cases} \quad \text{for } m=1, \dots, 8, 12 \quad ()$$



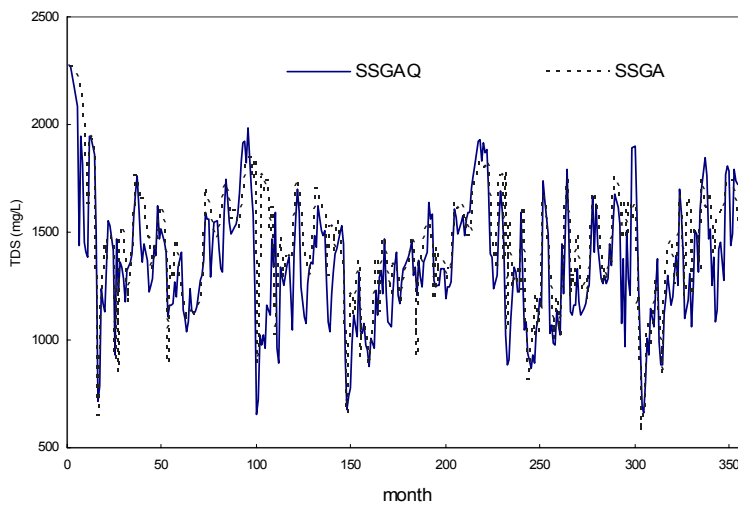
$$f_{c,m}(C_m) = \begin{cases} \bar{C}_m / 1900 & \text{if } \bar{C}_m < 1900 \\ 1 & \text{if } \bar{C}_m \geq 1900 \end{cases} \quad \text{for } m = 9, 10, 11 \quad ()$$

)

.(

(SSGAQ)

(SSGA)



:

SSGAQ - SSGA

TDS



11



()

Fontane, D.G., Gate, T.K., and Moncada, E., "Planning reservoir operations with imprecise objectives", *Journal of Water Resources Planning and Management, ASCE*, Vol.123, No.3., 1997.

Kaplan, E., "*Reservoir operation for water quality control*", Ph.D. dissertation, Univ. of Pa., Philadelphia, USA., 1974.



۱۲

-
- Kerachian, R., and Karamouz, M., “Waste-load allocation for seasonal river water quality management: application of sequential dynamic genetic algorithms”, *Journal of Scientia Iranica*, (Accepted/Forthcoming), 2004.
- Nandalal, K.D.W., and Bogardi, J., “Reservoir management for improving river water quality”, *Proceedings of the Int. Conference on Water Resources Management under Drought or Shortage Conditions*, Rotterdam. 1995.