



shamsai@sharif.ac.ir -
sarang@mehr.sharif.edu -

(Global Water Partnership-GWP)

(Integrated Water Resource Management-IWRM) ()

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IWRM .

IWRM

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USBR

IWRM

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Brundtland

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(GNP)

(ASCE)

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	Simonovic & McLaren
Kuik & Verbruggen.()
()
)	
(
):	Bossel
:	(Existence) ✓
:	(Freedom of Action , Functionality) ✓
Effectiveness, Efficiency, Simplicity,)	✓
:	(Input/Output
:	(Security,Risk) ✓
:	(Adaptability) ✓
:	(Carrying Capacity Integration Coexistence) ✓



: ✓

() Simonovic

(Resilience) (Reliability) (Vulnerability)

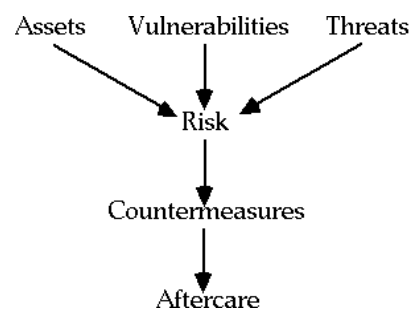
()

$$\text{Sustainability} = \text{Reliability} * \text{Resilience} * (1 - \text{Vulnerability})$$

(Robustness) ASCE

(Flexibility)

(Reversibility)



:(Zonation)



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National Sanitation) NSFQI

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) (Foundation,s Water Quality Index-US

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PMF

PMF

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(ICOLD,2000)

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✓

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✓

✓

✓

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✓

(MC)

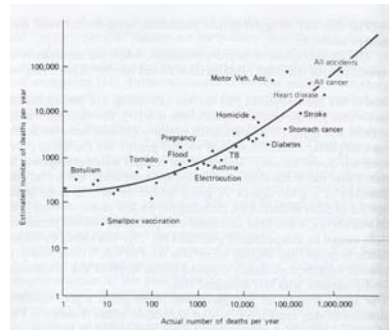
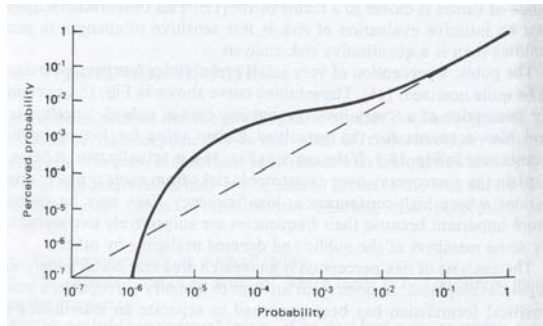
(DI)

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✓

(MFOSM)

() (AFOSM)



:

(ICOLD)

Socially Acceptable Risk))

((SAR

F

F/N

N

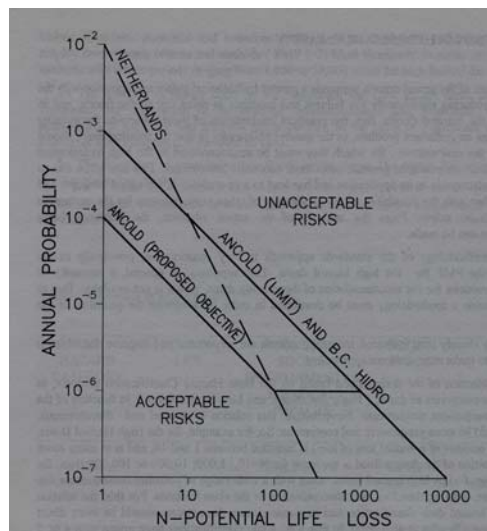
F/N

() ALARP

.()

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F/N

[Vincens et al.1975]



Natural)

- : •
 - : •
 - : •
- (Variability

. [Beck,1987]

. [Norkin et al.1994]

[Sobol,1965]

[Cardwell & Ellis,1993]

[Lohani&Hee, 1983]

()

(Chance Constrained Optimization)

:

(Combined Simulation and Optimization)

.(Multiple Realization)

:

:Reliability ✓

:Resiliency ✓

:Vulnerability ✓



$$\Theta^{(1)}(x) = \{\omega : S(x, \omega, t) \in \zeta^{(1)}, t = 1, \dots, T\},$$

$$\Theta^{(2)}(x) = \{\omega : S(x, \omega, t) \in \zeta^{(2)}, t = 1, \dots, T\} \setminus \Theta^{(1)}(x), \dots$$

$$\Theta^{(H)}(x) = \{\omega : S(x, \omega, t) \in \zeta^{(H)}, t = 1, \dots, T\} \setminus \Theta^{(H-1)}(x).$$

Willamette BOD - -
 DO BOD
 Oregon Willamette
 BOD
 ()

[Takyi & Lence, 1996]

BOD

BOD (Camp-Dobbins -) (Streeter-Phelps)
 DO DO

(mg/l-kg/day) BOD (mg/l) DO

BOD-DO

(DO) DO
)
 .(



Harrisburg

DO

(mg/l)

(mg/l)

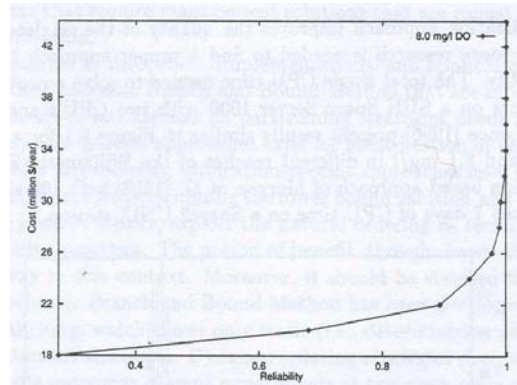
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(

(Reliability)

(Vulnerability)

(Resilience)



(mg/l)

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