```
sets
i Temporary Shelters /i1*i5/
j Distribution Centers /j1*j5/
k RDC's Size /k1*k3/
l Suppliers /l1*l3/
c Relief Commodities /c1,c2/
c1 Eco friendly Commodities /c11, c12/
c2 non-Eco friendly Commodities   /c21, c22/
s Scenarios /s1*s4/   ;

parameters
table F(j,k) fixed cost of estabilishing RDC with size k at location j
         j1      j2      j3      j4      j5
  k1     50000   50000   50000   50000   50000
  k2     80000   80000   80000   80000   80000
  k3     120000  120000  120000  120000  120000  ;
table h(j,c) holding cost for a unit c at RDC j
         c1      c2
j1       0.6     2.4
j2       0.6     2.4
j3       0.6     2.4
j4       0.6     2.4
j5       0.6     2.4    ;

table b(l,c1) purchasing cost of a unit with ecofriendly packaging c1 from l
         c11     c12
l1       0.7     2.8
l2       0.7     2.8
l3       0.7     2.8   ;
table b(l,c2) purchasing cost of a unit with non-ecofriendly packaging c2 from l
         c21     c22
l1       0.5     2
l2       0.5     2
l3       0.5     2            ;

table phi(j,l,c) transportation cost of a unit c from supplier l to RDC j
         l1.c1   l2.c1   l3.c1   l1.c2   l2.c2   l3.c2
j1       1.2     4.2     7.2     0.3     1.05    0.8
j2       3.6     3       7.8     0.9     0.75    1.95
j3       3.6     4.2     6       0.9     1.05    1.5
j4       7.2     7.2     3.6     1.8     1.8     0.9
j5       6       4.2     9       1.5     1.05    2.25 ;

parameter p(s) probability of scenario s
/s1      0.412,
s2        0.352,
s3        0.158,
s4        0.070/       ;

parameter b(l,c1,s) purchasing cost of a unit with ecofriendly packaging c1 from»
 l in scenario s  ;
b(l,c1,s)= b(l,c1)*p(s)  ;
parameter b(l,c2,s) purchasing cost of a unit with ecofriendly packaging c2 from»
 l in scenario s  ;
b(l,c2,s)= b(l,c2)*p(s)  ;
parameter phi(j,l,c,s) transportation cost of a unit c from supplier l to RDC j »
in scenario s ;
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phi(j,l,c,s)=phi(j,l,c)*p(s);
table phi(i,j,c) transportation cost of a unit c from RDC j to shelter i
          j1.c1   j2.c1   j3.c1   j4.c1   j5.c1   j1.c2   j2.c2   j3.c2   j4.c2  »
  j5.c2
i1        4.2     2.4     0.6     5.4     4.2     1.05    0.6     0.15    1.35   »
  1.05
i2        3.6     1.8     0.9     6.6     4.8     0.9     0.45    0.225   1.65   »
  1.2
i3        3       2.4     0.6     6       5.4     0.75    0.6     0.15    1.5    »
  1.35
i4        1.8     3       0.6     6.6     6       0.45    0.75    0.15    1.65   »
  1.5
i5        2.4     3.6     0.9     6       6       0.6     0.9     0.225   1.5    »
  1.5          ;
table phi(i,l,c) transportation cost of a unit c from RDC j to shelter i
          l1.c1   l2.c1   l3.c1   l1.c2   l2.c2   l3.c2
i1        5.4     4.2     8.4     1.35    1.05    2.1
i2        4.8     3.6     9.6     1.2     0.9     2.4
i3        4.2     4.2     9       1.05    1.05    2.25
i4        3       4.8     9.6     0.75    1.2     2.4
i5        3.6     5.4     9       0.9     1.35    2.25                         ;
parameter phi(i,l,c,s) transportation cost of a unit c from supplier l to shelte»
r j in scenario s ;
phi(i,l,c,s)=phi(i,l,c)*p(s);
table d(i,c,s) demand for relief item c at shelter i in scenario s
          i1.c1   i2.c1   i3.c1   i4.c1   i5.c1   i1.c2   i2.c2   i3.c2   i4.c2  »
  i5.c2
s1        270000  472500  40500   162000  43693   180000  315000  27000   108000 »
  29129
s2        270000  472500  40500   2072    0       180000  315000  27000   1382   »
  0
s3        270000  12807   0       0       0       180000  8538    0       0      »
  0
s4        270000  472500  40500   162000  55006   180000  315000  27000   108000 »
  36670   ;
parameter teta(c) required unit space for relief item c(m^3)
/c1       0.0045,
c2        0.002/            ;
table v(l,c1) amount of relief item c1 that could be supplied form l
          c1
l1        324000
l2        162000
l3        324000  ;
table v(l,c2) amount of relief item c2 that could be supplied form l
          c2
l1        216000
l2        108000
l3        216000  ;
parameter v(l,c1,s)   amount of relief item c1 that could be supplied form l in »
scenario s ;
v(l,c1,s)=v(l,c1)*p(s);
parameter v(l,c2,s)   amount of relief item c2 that could be supplied form l in »
scenario s ;
v(l,c2,s)=v(l,c2)*p(s);
parameter V(k) type of capacity for RDC /k1     20000, k2        32000, k3     »
  48000/   ;
table lambda(j,c1,s) fraction of stored relief item c1 at RDC j that remains us»
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able in scenario s
          c11   c12
j1        1     0.67
j2        1     0.67
j3        1     0.67
j4        1     0.67
j5        1     0.67   ;
table lambda(j,c2,s) fraction of stored relief item c2 at RDC j that remains us»
able in scenario s
          c21     c22
j1        0.33    0.67
j2        0.33    0.67
j3        0.33    0.67
j4        0.33    0.67
j5        0.33    0.67   ;

table beta(i,c,s) critically degree of relief item c at shelter i in scenario s
                  s1      s2      s3      s4
i1.c1             0.6     0.6     0.6     0.6
i2.c1             0.6     0.6     0.6     0.6
i3.c1             0.6     0.6     0.6     0.6
i4.c1             0.6     0.6     0.6     0.6
i5.c1             0.6     0.6     0.6     0.6
i1.c2             0.4     0.4     0.4     0.4
i2.c2             0.4     0.4     0.4     0.4
i3.c2             0.4     0.4     0.4     0.4
i4.c2             0.4     0.4     0.4     0.4
i5.c2             0.4     0.4     0.4     0.4  ;
parameter bhat(l,c1) environmental effects of c1 procured from l;
bhat(l,c1)=0.1*b(l,c1);
parameter bhat(l,c2) environmental effects of c2 procured from l;
bhat(l,c2)=0.1*b(l,c2);
parameter phihat(i,j,c,s) amount of carbon emission due to transportation of an »
item c from RDC j to shelter i in scenario s;
phihat(i,j,c,s)=0.1*phi(i,j,c,s);
parameter phihat(i,l,c,s) amount of carbon emission due to transportation of an »
item c from supplier l to shelter i in scenario s;
phihat(i,l,c,s)= 0.1*phi(i,l,c,s);
parameter phihat(j,l,c) amount of carbon emission due to transportation of an i»
tem c from supplier l to RDC j;
phihat(j,l,c)=0.1*phi(j,l,c);
variables
I(j,c)   amount of relief item c stored in RDC j (Inventory level)
I(j,c,s)   amount of relief item c stored in RDC j in scenario s (Inventory leve»
l)
X(j,k)   1 if RDC with capacity category k is opened at location j otherwise 0
y(i,j,c,s) amount of relief item c transfered from RDC j to shelter i in scenari»
o s
y(i,l,c,s) amount of relief item c transfered from supplier l to shelter i in sc»
enario s
y(i,l,c1,s) amount of relief item c1 transfered from supplier l to shelter i in »
scenario s
y(i,l,c2,s) amount of relief item c2 transfered from supplier l to shelter i in »
scenario s
Q(j,l,c1) order quantity of c1 from supplier l to RDC j
Q(j,l,c2) order quantity of c2 from supplier l to RDC j
Q(j,l,c1,s) order quantity of c1 from supplier l to RDC j in scenario s
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Q(j,l,c2,s) order quantity of c2 from supplier l to RDC j in scenario s
Q(j.l.c) amount of relief item c purchansed from supplier l by RDC j
Q(j.l.c,s) amount of relief item c purchansed from supplier l by RDC j scenario s
alpha(i,c,s)  satisfaction rate of shelter i for relief item c in scenario s
alpha(s) minimum satisfaction rate among all shelters for all kind of goods in scenario s
z total logistics cost;
binary variable X;
positive integer variables I,y,Q;
positive variable alpha ;



equations
Objective1       minimization logistics cost
Objective2       maximization of minimum satisfaction rate
Objective3       minimization of enviromental effects
constraint1(j,l,c,c1,c2)   order quantity balance
constraint2(j,l,c,c1,c2,s) order quantity balance in scenarios
constraint3(j,c) inventory balance
constraint4(j,c,c1,c2,s) inventory balance of each relief package in scenario
constraint5(j,c,s)       inventory level
constraint6(j)   RDC capacity
constraint7(j,s) RDC capacity in scenarios
constraint8(j)   RDC location
constraint9(l,c1)        Supplier Capacity
constraint10(l,c2)       Supplier Capacity
constraint11(l,c1,s)     Supplier Capacity in scenario
constraint12(l,c2,s)     Supplier Capacity in scenario
constraint13(i,l,c,c1,c2,s)      shipped items ballance
constraint14(i,c,s)      Post disaster demand management
constraint15(i,c,s)      Post disaster demand management
constraint16(i,s)        linearization of objective2 ;

objective1 .. z =e= sum((j,k),F(j,k)*X(j,k))+ sum((j,c),h(j,c)*I(j,c))+sum((j,l,c1),b(l,c1)*Q(j,l,c1))+sum((j,l,c2),b(l,c2)*Q(j,l,c2))
+sum((j,l,c),phi(j,l,c)*Q(j,l,c))+sum(s,p(s)*(sum((j,c),h(j,c))*(I(j,c,s)-sum(i,y(i,j,c,s)))+sum((j,l,c1),b(l,c1,s)*Q(j,l,c1,s))+sum((j,l,c2),b(l,c2,s)*Q(j,l,c2,s))
+sum((j,l,c),phi(j,l,c,s)*Q(j,l,c,s))+sum(i,j,c),phi(i,j,c,s)*y(i,j,c,s))+sum((i,l,c),phi(i,l,c,s)*y(i,l,c,s)));
Objective2 .. sum(s,p(s)*alpha(s)) ;
Objective3 .. sum((j,l,c1),bhat(l.c1)*Q(j,l,c1))+sum((j,l,c2),bhat(l.c2)*Q(j,l,c2))+sum((j,l,c),phihat(j,l,c)*Q(j,l,c))+sum(s,p(s)*(sum((j,l,c1),bhat(l,c1)*Q(j,l,c1,s))
+sum((j,l,c2),bhat(l,c2)*Q(j,l,c2,s))+sum((j,l,c),phihat(j,l,c)*Q(j,l,c,s))+sum((i,j,c),phihat(i,j,c,s)*y(i,j,c,s))+sum((i,l,c),phihat(i,l,c,s)*y(i,l,c,s)))

constraint1(j,l,c,c1,c2) .. Q(j,l,c)=e=Q(j,l,c1)+Q(j,l,c2);
constraint2(j,l,c,c1,c2,s) .. Q(j,l,c,s)=e=Q(j,l,c1,s)+Q(j,l,c2,s);
constraint3(j,c) .. I(j,c)=e=sum(l,Q(j,l,c));
constraint4(j,c,c1,c2,s) ..   I(j,c,s)=e=sum(l,Q(j,l,c,s))+lambda(j,c1,s)*sum(l,Q(j,l,c1))++lambda(j,c2,s)*sum(l,Q(j,l,c2)) ;
constraint5(j,c,s) .. sum(i,y(i,j,c,s))=l=I(j,c,s);
constraint6(j) .. sum(c,teta(c)*I(j,c))=l=sum(k,V(k)*X(j,k));
constraint7(j,s)..   sum(c,teta(c)*I(j,c,s))=l=sum(k,V(k)*X(J,k));
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constraint8(j) ..  sum(k,X(j,k))=l=1;
constraint9(l,c1) .. sum(j,Q(j,l,c1))=l=v(l,c1) ;
constraint10(l,c2) .. sum(j,Q(j,l,c2))=l=v(l,c2) ;
constraint11(l,c1,s) .. sum(j,Q(j,l,c1,s))+sum(i,y(i,l,c1,s))=l=v(l,c1,s);
constraint12(l,c2,s) .. sum(j,Q(j,l,c2,s))+sum(i,y(i,l,c2,s))=l=v(l,c2,s);
constraint13(i,l,c,c1,c2,s).. y(i,l,c,s)=y(i,l,c1,s)+y(i,l,c2,s);
constraint14(i,c,s).. alpha(i,c,s)=e=((sum(j,y(i,j,c,s))+sum(l,y(i,l,c,s)))/d(i,c,s));
constraint15(i,c,s)..alpha(i,c,s)=l=1;
constraint16(i,s).. alpha(s)=l=((sum(c,alpha(i,c,s)*beta(i,c,s)))/sum(c,beta(i,c,s)));
model cost/all/;
solve cost using MILP minimizing objective1;
display objective1, I ,y , Q, X, alpha;
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