```
$ EOLCOM //
$ TITLE Optimizing Water Resource Use in the TE Basin - Iraq
$ OFFLISTING

OPTIONS LIMROW = 0, LIMCOL = 0

$ONTEXT
EOLCOM // tells GAMS to ignores everything in a line after the symbol //
OFFLISTING deletes all program lines and just includes GAMS results saves paper

Set LIMROW = 0 to eliminate all equations in the GAMS listing
Set LIMROW = 100 or more to show all equations in listing. Can help trap errors
Set LIMCOL = 0 to eliminate starting values of all variables (rarely needed).

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* ------------------------------------------------------------------------------
*  Model 1: Simple Farm Management: optimizes (maximizes) total farm income
*  2 crops and 1 province
*  Limited water,  Unlimited land
* ------------------------------------------------------------------------------
$OFFTEXT
```

```
****************************************   Section 1 ***********************************
*                                           Sets                                       *
****************************************************************************************

SETS

k  crop

/  1-Wheat
   2-Cotton
/

***************************  Section 2 ***********************************************************************
*                               Data                                                                         *
**************************************************************************************************************

parameter  Bc(k)    crop water demand (ET)    (1000s cubic meters per Ha = 10ths of meters depth)

/1-wheat   11.9
 2-cotton  18.0/

*Bc(k) =  0.5 * Bc(k)

parameter    Yield_p(k) Crop Yield - often proportional to ET    (tons per Ha)

/1-wheat    1.39
 2-cotton   2.32
/

* economic data

Parameter   Price_p(k)  Crop Prices                             ($ US per ton)

/1-Wheat    225
 2-Cotton   906
/

parameter Cost_p(k)   Production costs excluding water           ($US per Ha)

/1-wheat    200
```

```
 2-cotton  1286/

parameter Wat_supply_p   total water available                   (million cubic meters per year)

/572/

Parameter Net_revenue_p(k)  calculated net revenue per unit land ($ US per Ha)
;

Net_revenue_p(k) = Price_p(k) * Yield_p(k) - Cost_p(k);

***********************************************  Section 3 ***********************************************
*                                                Variables                                                *
*********************************************************************************************************
positive variables

hectares_v   (k)      land in production by crop       (1000 Ha - marginal is $US per Ha)
T_hectares_v          total land in production         (1000 Ha - marginal is $US per Ha)
uses_crop_v  (k)      total water use by crop          (million m^3 - marginal is $US per 1000 m^3)
uses_v                total water use                  (million m^3 - marginal is $US per 1000 m^3)

variables
ag_ben_k_v   (k)      total farm income by crop        ($US 1000s - no marginals shown)
ag_ben_v              summed farm income (objective)    ($US 1000s - no marginals shown)

**********************************************  Section 4  *********************************************
*                                                Equations                                               *
********************************************************************************************************

// equations declared (named)

Equations

T_hectares_e          total land in production         (1000 Ha -  marginal is $US per Ha)
Uses_crop_e  (k)      total water use by crop          (million m^3 - marginal is $US per 1000 m^3)
uses_e                total water use                  (million m^3 - marginal is $US per 1000 m^3)

ag_ben_k_e   (k)      total farm income by crop        ($US 1000s - no marginals shown)
ag_ben_e              total farm income (objective)    ($US 1000s - no marginals shown)
;
```

```
// equations defined (uses declared names to write with algebraic formulas)

T_hectares_e   ..   T_hectares_v     =e=  sum(k,   hectares_v(k));          // sums land in prodn over crops
Uses_crop_e (k)..   uses_crop_v (k)  =e=   Bc(k) * hectares_v(k);           // total water use by crop
uses_e         ..   uses_v           =e=  sum(k,  uses_crop_v(k));          // total water use summed over crops
ag_ben_k_e  (k)..   ag_ben_k_v  (k)  =e=  net_revenue_p(k) * hectares_v(k); // total farm income by crop
ag_ben_e       ..   ag_ben_v         =e=  sum(k,   ag_ben_k_v(k));          // objective fn:  total farm income

*********************************** Section 5 ***************************************************************
*  labels and defines all models used                                                                       *
*  Each model has one objective
*****************************************************************************************************************

model TE_01 /all/;                                          // uses all equations above

***********************************  Section 6   ***************************************************************
*                                    Bounds                                                                 *
*  Setting bounds helps you discover shadow price (economic value) for each limiting resource               *
*****************************************************************************************************************

uses_v.up = wat_supply_p;          // upper bound on total water availablem, avoids unbounded solution
*uses_crop_v.lo('wheat')  =  100;  // lower bound on water assigned to wheat

*********************************** Section 7 ***************************************************************
*                                  SOLVE THE MODEL                                                          *
*****************************************************************************************************************

solve TE_01 using nlp maximizing ag_ben_v;  // uses nonlinear programming solver

*********************************** THE END *****************************************************************
```