```
! A5 farm HH model - Carbon Project (CA);

MODEL: TITLE CA;

SETS:

HH/1..110/:

!------------------General variables to be calculated (Output
data)-------------------------------------
TFR= Total farm net revenue from agriculture [1000 IDR/yr], FamilyLab=Total family Labour
availability,
Tot_expenses= total household expenses (1000 IDR/yr), Totalincome= total household income
(1000 IDR/yr),
New_area= new farm area converted from forest (ha/yr), Lab_newarea= labour for converting
new farm area (h/yr),
Cost_newarea= costs for converting new farm area (1000 IDR/yr), Rest_labour= unused labour
per period (h/yr),
Rest_cash=unused cash per year (1000 IDR/yr);

MAX_TFR, FamilyLab, TOT_expenses, Totalincome,
New_area, Lab_newarea, Cost_newarea, Rest_labour, Rest_cash,



!-------------------General input
variables-----------------------------------------------
(id= Household ID, AME= Adult Male Equivalents,
Farmarea/Totarea= Total available Farm area [ha], d_Napu= Napu valley (0/1), d_Palolo=
Palolo valley (0/1,
d_Palu= Palu valley (0/1), d_Kulawi= Kulawi valley (0/1));
id, AME, Farmarea, d_Napu, d_Palolo, d_Palu, d_Kulawi,Totarea,


!#########################################################################################
;

!-----------------COCOA variables to be
calculated---------------------------------------
MAX_Rev_coc= Total net revenue from Cocoa [1000 IDR/yr], MAX_Rev_coc= Total net revenue
from Cocoa [1000 IDR/yr],
MAX_Inc_coc= Total income from Cocoa [1000 IDR/yr], Prodcosts_coc [1000
IDR/yr],MAX_Yieldha_coc= cocoa yield per ha [kg/yr],
MAX_Yield_coc= total cocoa yield [kg/yr], Change_land_coc= change in cocoa land [ha],
OPT_Lab_coc=labour dedicated to cocoa [h/yr]
Change_Openness= Change in canopy openness [%], Lab_Change_Openness= labour for changing
canopy openness (h/yr),
Cost_new_coc=costs for new cocoa area (1000 IDR/yr), Lab_new_coc=labour for new cocoa area
(h/yr);
MAX_Rev_coc, MAX_Inc_coc, Prodcost_coc, MAX_Yieldha_coc, MAX_Yield_coc, Change_land_coc,
OPT_Lab_coc,
Change_Openness, Lab_Change_Openness,
Cost_new_coc, Lab_new_coc,

!-----------------COCOA input
variables-----------------------------------------------------;
!(Price_coc= Cocoa producer price on village level[1000 IDR/kg];
Price_coc,

!RF= 1000 Rainfall[mm/yr], Ptot= Total Soil Phosphor content [kg ha-1],
DF= Distance to forest edge [km], d_WL= waterlogging soil conditions (0/1), t_TW= Total
working time [h/yr],
SP_c/PS_c= Cocoa area [ha], TA= average cocoa tree age, OP/Open= openness [%], d_CPB=
heavy damage by Cocoa Pod Borer (0/1),
d_FT = Forest trees on plot (0/1), IP_ha= Material inputs per ha [1000 IDR/yr], IP= total
material inputs (1000 IDR/yr),
pd_IP=no material input (0/1),PD= planting density (cocoa trees per ha), PD2= planting
```

```
densitsy squared,
Inc_icrops_ha= income from intercrops [1000 IDR/ha/yr], Matexp_ha= Material expenses [1000
IDR/ha/yr],
Labexp_c_ha= Labour expenses cocoa [1000 IDR/ha/yr], Transexp _c_ha= Transport expenses
cocoa [1000 IDR/ha/yr],
Labexp_icrops_ha= Labour expenses intercrops[1000 IDR/ha/yr]);
RF, Ptot, DF, d_WL, t_TW, SP_c, PS_c,TA, OP, Open, d_CPB, d_FT, IP_ha, pd_IP, PD, PD2,
Inc_icrops_ha,
Matexp_c_ha, Labexp_c_ha,Transexp_c_ha, Labexp_icrops_ha,
Area_coc, Area_c,
! ****************************************;
! ****************************************;
index,
! ****************************************;
! ****************************************;

!#########################################################################################
;

!----------------RICE variables to be
calculated-----------------------------------------------
Max_Rev_rice= Net revenue from Rice [1000 IDR/yr], Max_Inc_rice= Income from Rice [1000
IDR/yr],
Max_Yieldha_rice= Rice yield per ha [kg/yr], Max_Yield_rice= Total Rice yield[kg/yr],
Prodcost_rice= Variable Costs Rice [IDR/yr], Change_Land_rice=change in rice land (ha/yr),
Cost_new_rice=cost for new rice area (1000 IDR/yr), Lab_new_rice=labour for new rice area
(h/yr),
OPT_Lab_rice= Labour use for Rice [h/yr], OPT_Purch_rice=purchased rice for comsumption
(kg/yr);
MAX_Rev_rice, MAX_Inc_rice, MAX_Yieldha_rice, MAX_Yield_rice, Prodcost_rice,
Change_Land_rice, Cost_new_rice, Lab_new_rice, OPT_Lab_rice, OPT_Purch_rice,

!-----------------RICE input
variables-----------------------------------------------------
Price_rice= Rice producer price on village level [1000 IDR/kg];
Price_rice,

!Cons_price_r=Rice consumer price on village level [1000 IDR/kg];
Cons_price_r,

!SP_r/PS_r= Rice area [ha], Pexp_r_ha= Pesticide expenses per ha[1000 IDR/crop],
Fexp_r_ha= Fertilizer expenses [1000 IDR/crop], pd_fert_r= no Fertilizer use (1/0),
pd_pest_r= no Pesticide use (1/0),
d_HYV_r= High yielding variety (0/1), No_crop_r= number of crops per year,
Irriexp_r_ha= Expenses for rice irrigation [1000 IDR/ha/crop], Procexp_r_ha= Expenses for
rice processing [1000 IDR/ha/crop],
Transexp_r_ha= Expenses for rice transport [1000 IDR/ha/crop], Seedexp_r_ha= Expenses for
rice seeds [1000 IDR/ha/crop],
Prepexp_r_ha= Expenses for rice field preparation [1000 IDR/ha/crop], Lab_rice= Labour
requirement for Rice [h/ha/crop];

SP_r, PS_r, Pexp_r_ha, Fexp_r_ha, pd_fert_r, pd_pest_r, d_HYV_r,
No_crop_r, Irriexp_r_ha, Procexp_r_ha, Transexp_r_ha, Seedexp_r_ha, Prepexp_r_ha,
Area_rice, Area_r,

!#########################################################################################
##;

!----------------MAIZE variables to be
calculated-----------------------------------------
Max_Inc_maize= Income from Maize [1000/yr], Max_Yieldha_maize= Maize yield per ha
[kg/crop],
Max_Yield_maize= Total Maize yield [kg/crop], Prodcost_maize= Variable Costs Maize [1000
IDR/yr],
Change_Land_maize= new maize land [ha/yr],Cost_new_maize=cost for new maize area [1000
IDR/yr],
Lab_new_maize=labour for new maize area [h/yr],OPT_Lab_maize= Labour use for Maize [h/a];
```

```
MAX_Rev_maize, MAX_Inc_maize, MAX_Yieldha_maize, MAX_Yield_maize, Prodcost_maize,
Change_Land_maize,
Cost_new_maize, Lab_new_maize, OPT_Lab_maize,

!-----------------MAIZE input
variables-----------------------------------------------------
Price_maize= Maize producer price [1000 IDR/kg];
Price_maize,

!SP_m/PS_m= Maize area [ha], Pexp_m_ha= Pesticide expenses per ha[1000 IDR/crop],
Fexp_m_ha= Fertilizer expenses per ha [1000 IDR/crop], pd_fert_m= no Fertilizer use (1/0),
pd_pest_m= no Pesticide use (1/0), d_HYV_m= High yielding variety (0/1),
No_crop_m= number of crops per year, Procexp_m_ha= Expenses for maize processing
[Rp/crop/ha],
Transexp_m_ha= Expenses for maize transport [Rp/crop/ha], Seedexp_m_ha= Expenses for maize
seeds [Rp/crop(ha],
Prepexp_m_ha= Expenses for maize field preparation [Rp/crop/ha]), Lab_maize= Labour
requirement for maize [h/ha/crop];

SP_m, PS_m, Fexp_m_ha, Pexp_m_ha, pd_fert_m, pd_pest_m, d_HYV_m, No_crop_m, Procexp_m_ha,
Transexp_m_ha, Seedexp_m_ha, Prepexp_m_ha,
Area_maize, Area_m,

!#########################################################################################
##;

!Other inputs: Area_coffe= total coffee area [ha], Area_veg= total vegetable area [ha];
Area_coffee, Area_veg, OF,
Carbon_income, REDD_inc, Sequest_inc;

ENDSETS

!#########################################################################################
####;



DATA:

! ***************************************;
! ***************************************;
index  = 1;
! index = 1 2 3 4 5 6 7 8 9  10  11  14  13  14  15  16  17  18 19  20  21  22  23  24  25
26  27  28  29  30  31  32  33  34  35  36 37  38  39  40  41  42  43  44  45  46  47  48
49  50  51  52  53  54 55  56  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71
72 73  74  75  76  77  78  79  80  81  82  83  84  85  86  87  88  89  90 91  92  93  94
95  96  97  98  99 100 101 102 103 104 105 106 107 108 109 110 111 114 113 114 115 116 117
118 119 140 141 142 143 144 145 146  147 148 149 130 131 132 133 134 135 136 137 138 139
140 141 142 143 144  145 146 147;
! ***************************************;
! ***************************************;

!---------------------------------
general-----------------------------------------------------;

id Totarea AME d_Kulawi d_Palu d_Palolo d_Napu Rest_cash

!#########################################################################################;
!----------------------Production
data----------------------------------------------------------

---------------------------
COCOA---------------------------------------------------------------;
RF Ptot DF d_WL
TA d_CPB d_FT OP pd_IP PD PD2 PS_c IP_ha
Inc_icrops_ha Matexp_c_ha Labexp_c_ha Transexp_c_ha Labexp_icrops_ha
```

```
Area_c
Price_coc
= @ODBC ('model_db', 'Prod_Dataset_new');


!#########################################################################################
####;


!------------------------RICE
-------------------------------------------------------------;

d_HYV_r No_crop_r pd_fert_r pd_pest_r Fexp_r_ha Pexp_r_ha PS_r
Irriexp_r_ha Procexp_r_ha Transexp_r_ha Seedexp_r_ha Prepexp_r_ha
Price_rice Cons_price_r
Area_r
=@ODBC ('model_db', 'Prod_Dataset_new');

!Labour requirement rice: average value Gessert (2007)(1099 h/ha/crop);
Lab_rice=1100;



!#########################################################################################
##########;


!-----------------------
MAIZE----------------------------------------------------------------;

Fexp_m_ha Pexp_m_ha pd_fert_m pd_pest_m d_HYV_m No_crop_m PS_m
 Procexp_m_ha Transexp_m_ha Seedexp_m_ha Prepexp_m_ha
Price_maize
Area_m
=@ODBC ('model_db', 'Prod_dataset_new');


!Labour requirement maize: average value Keil (2007) (220.64 h/ha/crop);
Lab_maize=220;

!#########################################################################################
############;

!--------------
Other---------------------------------------------------------------;
Area_coffee Area_veg OF
=@ODBC ('model_db', 'Prod_Dataset_new');


!#########################################################################################
##########;

!-----------------
OUTPUT--------------------------------------------------------------;

@ODBC('model_db','Prod_Dataset_new')
= MAX_TFR, MAX_Rev_coc, MAX_Rev_rice, MAX_Rev_maize,
MAX_Inc_coc, MAX_Inc_rice, MAX_Inc_maize,Totalincome,
MAX_Yieldha_coc,MAX_Yieldha_rice, MAX_Yieldha_maize,
MAX_Yield_coc, MAX_Yield_rice, MAX_Yield_maize,
Prodcost_coc, Prodcost_rice, Prodcost_maize, PS_c, PS_r, PS_m, Totarea, Area_c, Area_r,
Area_m, OP, Rest_cash, Rest_labour,
OPT_Lab_coc,OPT_Lab_rice, OPT_Lab_maize, Change_Land_coc, Change_Land_rice,
Change_Land_maize,
Cost_new_coc, Cost_new_rice, Cost_new_maize, Lab_new_coc, Lab_new_rice, Lab_new_maize,
TOT_expenses, OPT_Purch_rice, FamilyLab,
```

```
Carbon_income, Sequest_inc, REDD_inc;

ENDDATA

!#############################################################################################
####;

INIT:

farmarea,
!------------
COCOA-----------------------------------------------------------------------------;

t_TW, SP_c, Open=@ODBC ('model_db', 'Prod_Dataset_new');


!------------
RICE------------------------------------------------------------------------------;
SP_r
=@ODBC ('model_db', 'Prod_Dataset_new');

!Purch_rice=20;

!------------
MAIZE-----------------------------------------------------------------------------;
SP_m
=@ODBC ('model_db', 'Prod_Dataset_new');


!labcoeff_c==@ODBC ('model_db', 'Lab_coeff10');


ENDINIT


!#############################################################################################
###;



SUBMODEL OPT:

!-------------------------Objective
Function-------------------------------------------------;

! Objective: Maximise total farm revenue TFR;

[obj] MAX=TFR;

[T_Rev] TFR= Rev_coc+Rev_rice+Rev_maize+Carbon_inc;

ENDSUBMODEL

!#############################################################################################;


SUBMODEL COCOA:
!-------------------------COCOA Production-----------------------------------------------;

!-----Calculation of age curve for cocoa production
function-----------------------------;


[AG] Age= @EXP(3.82-0.0086*_TA+1.33*@LOG(_TA));
```

```
!-----Calculation of site-specific sub-model for cocoa production
function------------------;

[SITE] Site_coc= -727.1+ _RF*505.2+_Ptot*95.1+_DF*80.87+_d_WL*-195.96;


!Cocoa production function (Cobb_Douglas);


Yield_coc=@EXP(-9.77)*t_TW(j) ^0.16*((SP_c(j)^0.735)*(1-(SP_c(j)*0.12)))*(((_IP_ha*SP_c
(j))^0.202)*(1-(SP_c(j)*0.12)))* Age^0.933*Open(j)^0.333*(((_PD*SP_c(j))^1.391)*(1-(SP_c
(j)*0.12)))*(((_PD2*SP_c(j))^-0.12)*(1-(SP_c(j)*0.12)))*Site_coc^0.554*@EXP(_d_CPB*-0.321)
*@EXP(_d_FT*-0.481)*@EXP(_pd_IP*0.891);

!-----------------------------------------------------------------------------------------
--;


!Income from cacao ;
[C_Inc] Inc_coc=(_Inc_icrops_ha* SP_c(j))+(Yield_coc*_Price_coc);


! Expenses for cocoa ;
[C_Exp] Exp_coc=(_Matexp_c_ha+_Labexp_c_ha+_Transexp_c_ha+_Labexp_icrops_ha+_IP_ha)*SP_c
(j);

!Net Revenue from cocoa;

[C_Rev] Rev_coc=Inc_coc-Exp_coc;



ENDSUBMODEL
!#########################################################################################
##;

SUBMODEL RICE:
!--------------------------
RICE----------------------------------------------------------------;
! Rice prodcution function (Cobb_Douglas);

[R_Y] Yield_rice=@EXP(6.05)*SP_r(j)^0.749*(_Pexp_r_ha*SP_r(j))^0.145*(_Fexp_r_ha*SP_r(j))^
0.175*@EXP(_pd_fert_r*0.457)*@EXP(_pd_pest_r*0.402)*@EXP(_d_HYV_r*0.137)*@EXP(_d_Kulawi*-
0.25);


!Income from rice (No_crop= number of crops per year);
[R_Inc] Inc_rice=Yield_rice*_No_crop_r*_Price_rice;

! Expenses for rice ;
[R_Exp] Exp_rice=
(_Fexp_r_ha+_Pexp_r_ha+_Irriexp_r_ha+_Procexp_r_ha+_Transexp_r_ha+_Seedexp_r_ha+_Prepexp_r
_ha)*SP_r(j)*_No_crop_r;

!Net revenue from rice;
[R_Rev] Rev_rice=Inc_rice-Exp_rice;


ENDSUBMODEL

!#########################################################################################
############;


SUBMODEL MAIZE:
```

```
!------------------------
MAIZE-------------------------------------------------------------------;
! Maize production function (Cobb-Douglas);

[M_Y] Yield_maize=@EXP(7.05)*SP_m(j)^0.766*@EXP(_d_HYV_m*0.341)*@EXP(_d_Palu*-0.33)*@EXP
(_d_Kulawi*-0.37);


!Income from maize (No_crop= number of crops per year);
[M_Inc] Inc_maize=Yield_maize*_No_crop_m*_Price_maize;

! Expenses for maize;
[M_Exp] Exp_maize=(_Fexp_m_ha+_Pexp_m_ha+
_Procexp_m_ha+_Transexp_m_ha+_Seedexp_m_ha+_Prepexp_m_ha)*SP_m(j)*_No_crop_m;

!Net revenue from maize;
[M_Rev] Rev_maize=Inc_maize-Exp_maize;


ENDSUBMODEL

!#########################################################################################
########;

!#########################################################################################
########;

SUBMODEL CONS:

!----------------------
CONSTRAINTS-------------------------------------------------------------------;

!-------------------LAND--------------------------------------------------;

!Land Constraint: total land used shall not exceed farmarea;
[A] SP_c(j)+SP_r(j)+SP_m(j)<=farmarea(j);


!Bounded change in new converted farm area;
@BND(0,Newarea,0.25);

Newarea=farmarea(j)-_Totarea;

!cost and labour needed for converting new farm area;
Costnewarea=@IF(Newarea#LE#0,0,Newarea*9703);
Labnewarea=@IF(Newarea#LE#0,0,Newarea*1047);


!Non-Negativity constraint;
SP_c(j)>=0;
SP_r(j)>=0;
SP_m(j)>=0;


!Bounded change in cropping areas of cocoa, rice and maize;
@BND(-0.25,Change_c,0.25);
Change_c=SP_c(j)-_Area_coc;

@BND(-0.25,Change_r,0.25);
Change_r=SP_r(j)-_Area_rice;

@BND(-0.25,Change_m,0.25);
Change_m=SP_m(j)-_Area_maize;


! Purchase and establ. cost for new cocoa, rice and maize area;
```

```
Cost_New_c=@IF(Change_c#LE#0,0,Change_c*10000);
Cost_New_r=@IF(Change_r#LE#0,0,Change_r*24600);
Cost_New_m=@IF(Change_m#LE#0,0,Change_m*5000);


! Labour input for new cocoa, rice and maize area;
Lab_New_c=@IF(Change_c#LE#0,0,Change_c*1047);
Lab_New_r=@IF(Change_r#LE#0,0,Change_r*1047);
Lab_New_m=@IF(Change_m#LE#0,0,Change_m*700);



!########################COCOA#########################################################;
!per ha yield boundaries;

@BND(0,Yield_coc_ha,3000);

!Yield per ha;
[C_Y_ha] Yield_coc_ha=Yield_coc/SP_c(j);


!per ha labour boundaries;
@BND (100,TW,2000);
[TL] TW=t_TW(j)/SP_c(j);

!bounded change in Openness;
@BND(-10,Change_OP,10);
Change_OP=Open(j)-_OP;

!Labour needed for changing Openness;
Lab_changeOP=@IF(Change_OP#LE#0,0,Change_OP*SP_c(j)*1.5);

!bounded Openness;
@BND(5,Open(j),97);



!Carbon sequestration and REDD project;

Carbon_inc= Sequest + REDD;

Sequest= @IF(Open(j)#GE#84.4,SP_c(j)*693.9,Sequest2);
Sequest2= @IF(Open(j)#GE#58.6,SP_c(j)*1363.3,Sequest3);
Sequest3= @IF(Open(j)#GE#37.1,SP_c(j)*1549.1,Sequest4);
Sequest4= @IF(Open(j)#LT#37.1,SP_c(j)*1997.3,0);

REDD=@IF(Newarea#GT#0,0,79.6);

!############################LABOUR#########################################################;

! Toatl labour used shall not exceed total labour availability;
[L] t_TW(j)+SP_r(j)*Lab_rice*_No_crop_r+SP_m(j)*Lab_maize*_No_crop_m+_Area_coffee*315
+_Area_veg*315+(_OF/20)
+Lab_new_c+Lab_new_r+Lab_new_m+Labnewarea+Lab_changeOP<=Labav;

!Labav= total Family labour availability [h/yr], family labour availability for
cropping:40% (Keil et al. 2009);
Labav=(_AME*7*23*12)*0.4;

!Labour not used in this period;
Restlabour=Labav-(t_TW(j)+SP_r(j)*Lab_rice*_No_crop_r+SP_m(j)
*Lab_maize*_No_crop_m+_Area_coffee*315+_Area_veg*315+(_OF/20)
+Lab_new_c+Lab_new_r+Lab_new_m+Labnewarea+Lab_ChangeOP);

!############################RICE#########################################################
######;
```

```
!per ha yield boundaries;
@BND(0,Yield_rice_ha,4000);

!Yield per ha;
[R_Y_ha] Yield_rice_ha=@IF(SP_r(j)#EQ#0,0,Yield_rice/SP_r(j));


!############################MAIZE#############################################
############;

!per ha yield boundaries;
@BND(0,Yield_maize_ha,3000);

!Yield per ha;
[M_Y_ha] Yield_maize_ha=@IF(SP_m(j)#EQ#0,0,Yield_maize/SP_m(j));


!############################REVENUES##########################################
############;

!Non-negativity constraint;
[RC] Rev_coc>=0;
Rev_rice>=0;
Rev_maize>=0;


!########################FOOD
CONSTRAINT#########################################################;


[RY_Min] (Yield_rice+Purch_rice)>=Min_cons_r;
!Minimum Rice consumption per HH: 147kg rice per AME (Keil et al. 2007);
Min_cons_r=_AME*147;

!Consumption constraint;
[P_R] Exp_purch_rice=Purch_rice*_Cons_Price_r;

!value of grown and purchased rice;
Val_rice= Exp_purch_rice+(Yield_rice*_Cons_Price_r);

!food expenditure without rice exp. (food expenditure is 70% of all exp./rice 30%);
Val_food=(Val_rice*2.3)-Val_rice;


!############################EXPENSES##########################################
##############;

!Capital contraint: total costs shall not exceed Total income +cash from previous period;
[C]
Exp_coc+Exp_rice+Exp_maize+Exp_purch_rice+Cost_New_c+Cost_New_r+Cost_New_m+Costnewarea+Val
_food<=Totinc+_Rest_cash+_OF;

!Cash not expended this period;
Restcash=Totinc-Tot_exp;

!Total income;
[TI] Totinc=Inc_coc+Inc_rice+Inc_maize+_OF;

!Total expenses;
Tot_exp=
Exp_coc+Exp_rice+Exp_maize+Exp_purch_rice+Cost_New_c+Cost_New_r+Cost_New_m+Costnewarea+Val
_food;


ENDSUBMODEL
!#############################################################################################
#;
```

```
!#############################################################################################
##;


CALC:



@FOR (HH(i):
! ******** ;
! ******** ;
 j = index(i);


! ******** ;
! ******** ;

!Input variables;

_AME=AME(i);

_Totarea=Totarea(i);
_d_Napu=d_Napu(i);
_d_Palu=d_Palu(i);
_d_Kulawi=d_Kulawi(i);
_d_Palolo=d_Palolo(i);

_Price_coc=Price_coc(i);
_Price_rice=Price_rice(i);
_Price_maize=Price_maize(i);
_Cons_price_r=Cons_price_r(i);


_RF=RF(i);
_Ptot=Ptot(i);
_DF=DF(i);
_d_WL=d_WL(i);
_t_TW=t_TW(i);
_PS_c=PS_c(i);
_Area_coc=Area_c(i);
_TA=TA(i);
_OP=OP(i);
_d_CPB=d_CPB(i);
_d_FT=d_FT(i);
_pd_IP=pd_IP(i);
_IP_ha=IP_ha(i);
_PD=PD(i);
_PD2=PD2(i);
_Inc_icrops_ha=Inc_icrops_ha(i);

_Matexp_c_ha=Matexp_c_ha(i);
_Labexp_c_ha=Labexp_c_ha(i);
_Transexp_c_ha=Transexp_c_ha(i);
_Labexp_icrops_ha=Labexp_icrops_ha(i);

_PS_r=PS_r(i);
_Area_rice=Area_r(i);
_Pexp_r_ha=Pexp_r_ha(i);
_Fexp_r_ha=Fexp_r_ha(i);
_pd_fert_r=pd_fert_r(i);
_pd_pest_r=pd_pest_r(i);
_d_HYV_r=d_HYV_r(i);
_No_crop_r=No_crop_r(i);
_Irriexp_r_ha=Irriexp_r_ha(i);
_Procexp_r_ha=Procexp_r_ha(i);
_Transexp_r_ha=Transexp_r_ha(i);
_Seedexp_r_ha=Seedexp_r_ha(i);
```

```
_Prepexp_r_ha=Prepexp_r_ha(i);

_PS_m=PS_m(i);
_Area_maize=Area_m(i);
_Pexp_m_ha=Pexp_m_ha(i);
_Fexp_m_ha=Fexp_m_ha(i);
_pd_fert_m=pd_fert_m(i);
_pd_pest_m=pd_pest_m(i);
_d_HYV_m=d_HYV_m(i);
_No_crop_m=No_crop_m(i);
_Procexp_m_ha=Procexp_m_ha(i);
_Transexp_m_ha=Transexp_m_ha(i);
_Seedexp_m_ha=Seedexp_m_ha(i);
_Prepexp_m_ha=Prepexp_m_ha(i);

_Area_coffee=Area_coffee(i);
_Area_veg=Area_veg(i);
_OF=OF(i);
_Rest_Cash=Rest_Cash(i);

!#########################################################################################
#;
!Solve Submodels;

@SOLVE (OPT, COCOA, RICE, MAIZE, CONS);


!#########################################################################################
####;

!Output variables;

MAX_TFR(i)= TFR;

MAX_Rev_coc(i)= Rev_coc;
MAX_Rev_rice(i)= Rev_rice;
MAX_Rev_maize(i)= Rev_maize;

MAX_Inc_coc(i)= Inc_coc;
MAX_Inc_rice(i)= Inc_rice;
MAX_Inc_maize(i)= Inc_maize;

Prodcost_coc(i)=Exp_coc;
Prodcost_rice(i)=Exp_rice;
Prodcost_maize(i)=Exp_maize;

New_area(i)=Newarea;

!---New input---------------;
Totarea(i)=farmarea(j);
PS_c(i)=SP_c(j);
PS_r(i)=SP_r(j);
PS_m(i)=SP_m(j);
OP(i)=Open(j);
Rest_cash(i)=Restcash;
Area_c(i)=_Area_coc+Change_c;
Area_r(i)=_Area_rice+Change_r;
Area_m(i)=_Area_maize+Change_m;
!----------------------------;

Change_Openness(i)=Change_OP;
Lab_Change_Openness(i)=Lab_changeOP;

Change_Land_coc(i)=Change_c;
Change_Land_rice(i)=Change_r;
Change_Land_maize(i)=Change_m;
```

```
Cost_new_coc(i)=Cost_new_c;
Cost_new_rice(i)=Cost_new_r;
Cost_new_maize(i)=Cost_new_m;

Cost_newarea(i)=Costnewarea;

Lab_new_coc(i)=Lab_new_c;
Lab_new_rice(i)=Lab_new_r;
Lab_new_maize(i)=Lab_new_m;

Lab_newarea(i)=Labnewarea;

MAX_Yield_coc(i)=Yield_coc;
MAX_Yield_rice(i)=Yield_rice;
MAX_Yield_maize(i)=Yield_maize;

MAX_Yieldha_coc(i)=Yield_coc_ha;
MAX_Yieldha_rice(i)=Yield_rice_ha;
MAX_Yieldha_maize(i)=Yield_maize_ha;

OPT_Lab_coc(i)=t_TW(j);
OPT_Lab_rice(i)=Lab_rice*_No_crop_r*SP_r(j);
OPT_Lab_maize(i)=Lab_maize*_No_crop_m*SP_m(j);

OPT_Purch_rice(i)=Purch_rice;

TOT_expenses(i)=Tot_exp;
Totalincome(i)=Totinc;

Rest_labour(i)=Restlabour;

FamilyLab(i)=Labav;

Carbon_income(i)=Carbon_inc;
REDD_inc(i)=REDD;
Sequest_inc(i)=Sequest;


!#############################################################################;

@release(TFR);
@release(Totinc);

@release(Rev_coc);
@release(Rev_rice);
@release(Rev_maize);

@release(Inc_coc);
@release(Inc_rice);
@release(Inc_maize);

@release(Exp_coc);
@release(Exp_rice);
@release(Exp_maize);

@release(Yield_coc);
@release(Yield_rice);
@release(Yield_maize);

@release(Yield_coc_ha);
@release(Yield_rice_ha);
@release(Yield_maize_ha);

@release(Min_cons_r);
@release(Exp_purch_rice);
@release(Val_rice);
@release(Val_food);
```

```
@release(Site_coc);
@release(Age);
@release(Change_OP);
@release(Lab_changeOP);

@release(Cost_New_c);
@release(Cost_New_r);
@release(Cost_New_m);

@release(Lab_New_c);
@release(Lab_New_r);
@release(Lab_New_m);

@release(Change_c);
@release(Change_r);
@release(Change_m);

@release(Newarea);
@release(Labnewarea);
@release(Costnewarea);

@release(TW);

@release(Labav);
@release(Tot_exp);
@release(Totinc);
@release(Restcash);
@release(Restlabour);
@release(REDD);
@release(Sequest);
@release(Carbon_inc);
);


ENDCALC

!#########################################################################################
##########;



END
```