MAD

Vitali G., Bazzani G.[1] Cardillo C.[2] Canavari M..[3]

1 Development & Programming, 2 RICA support , 3 Supervising

giuliano.vitali@unibo.it

1 Introduction

MAD is a **bio-economical model** aimed at optimising **farm management** in terms of best crops and distribution of surfaces surfaces, livestock diet accounting for on-frm available feedstock, fertilising management accounting for manure availability, labour and machinery, in order to **maximize the net income**. Optimization is performed by Linear Programming.

MAD has been formely developed within the project BIOSUS (MIPAAF 2011-2013) with the aim to estimate environmental sustainability index related to Italian farm management. GAMS is the development platform used for development.

MAD technical parameters are greatly derived from RICA, a FADN compliant data-set of a sample of about 10.000 holdings representing (by proper weights) the Italian holding Universe.

MAD may work on multiple farms and for a number of years to account for cost and price variability.

Model Description

MAD is a model that capture most relevant traits of a farm holding, introducing a lot of simplification allowing the model NOT to deal with ANY type of farms; here are the features of a MAD-farm:

- **each farm has unique**:

  - **climate**
  - **municipality**
  - **region**
  - **regime: Conventional or Organic**

- **holding can not perform pure animal husbandry:** Italian law (Cod.Civ.2135) states that holdings "without fields" are "industrial activities"

- livestock husbandry is based on **stables,** therefore grazing is neglected

- non productive (even potentially) surfaces (e.g. as buildings, lanes and edge fields, it:tare) are not considered

- natural area maintenance is neglected (no labour nor machinery);

- Each CROP corresponds to ONE technology, which technical parameters (costs, fuel, pesticides,...) depend on REGION (NUTS2), CLIMATE and SLOPE

- NO MIXED crops / POLYCULTUREs/ inter-cropping

- Electricity and Heat consumption are neglected

- crop management is related to machinery

  - machinery require fuel & management (ordinary & extraordinary)
  - machinery use is related to labour

- Labour is considered on a yearly basis even for seasonal activities (Working time is typically of: $1800 \simeq 8 \cdot 5 \cdot 45 \ h/pp \ year$);

  - seasonal salary fluctuation are not considered
  - seasonal availability of specialised workers is not considered.
  - **family labour for free is not allowed**

- farm is autonomous **- no contractors;**

  - machinery are owned by farmer
  - machinery is not considered

- fixed costs are not considered.

In MAD (base version) investments are not considered. It also means:

- livestock can grow to a limited extent (to prevent the need of building new stables)

- machinery renewal, upgrade and purchasing new tool is not allowed as well

Transformation processes are implicitly considered by production costs (e.g. tobacco leaf drying - it:cura), milk pasteurization, silaging: in those cases the presence of a technological post-harvest step reflects on detectable differences in prices

2   Constraints

Activities

Model considers 2 main types of surfaces (*cc*). The first type includes natural surfaces, fruit-tree plants, woody plants and breeding activities, whose surfaces (SCC) are considered not to vary during the analysis period:

$$SCC_{cc} = SCC.ini_{cc}$$

The second types is given by field crops. Arable land (SRA) is occupied by a set of crops which has an initial distribution which is optimised by the model by different options. Crops may be asked to attain a **cropping scheme** which is defined in terms of **crop types**; each **crop type** is given by one of more crops (*cr* ∈ *cc*) depending on the region (fgr); the resulting set of constraints is the following:

$$SRA \quad \equiv \quad \sum SCC_{cr}$$

Animal number in livestock (NBB, uba) can be optimised as well, allowing an increase on the base of parameter fzm which accounts for possibility of stables to host a number of animals larger than initial one.

Products

Activities are related to productions MPA. DPC and DPZ are the correspondence tables respectively for crops (cc) and livestock type (*bb*) is specified by DPC for crops and DPZ for livestock:

$$MPA_{pp} \quad = \quad \sum_{cc} SCC_{cc} \cdot fpp_{pp} \cdot DCP_{cc,pp}$$

$$MPA_{pp} \quad \equiv \quad \sum_{bb} NBB_{bb} \cdot fzt_{bb} \cdot DBZ_{bb,pp}$$

where fpp and fzt are yields per unit surface and livestock unit respectively.

Several types of products per activity may be available though. Most of plants and field crops make fresh or dry soldable product (MPS).

Products as herbage (also from pasture, fixed surfaces) can be transformed into forage or silage, and all of them can go to the market or REUSED within the farm (MPR) as foodstock. In general the following constraint is used:

$$MPA_{pp} \quad +MPP_{pp} = \quad MPS_{pp} + MPR_{pp}$$

There is a particular by-product as straw ($p2$), which can be directed to the market ($M2S$) or reused for stables: such a demand is related to cattle size, and when not satisfaied in farm is forced to be purchased ($M2P$):

$$MPA_{pp} + M2P \quad = \quad M2S + \sum_{bb} NBB_{bb} \cdot f2z_{bb}$$

where $f2z$ is straw requirement table (for cattle only).

Fertilizing

About plant fertilisers, together with the purchsed ones, nutrients available on farm are accounted for (from slurries/manure, yx) and a balance is required per nutrient ($nn = N, P, K$) :

$$\sum_{cc} MFC_{cc} \cdot fcn_{cc,nn} \quad \leftrightarrows \quad \sum_{ff} MFP_{ff} \cdot ffn_{pp,nn} + \sum_{yx} MPA_{yx} \cdot fpn_{pp,nn}$$

Livestock Feeding

Livestock nutrition is described in terms of DIET COMPONENTS where a fit is required between livestock requirements obtained by per-unit requirements (fdz) and those supplied, which in turn are made of available on-farm and purchased (MPP): diet components of products are specified in fdp. For a subset of elements is required a minimum, for other a

$$\sum_{bb} NBB_{bb} \cdot fdz_{bb,dd} \quad \leftrightarrows \quad \sum_{pp} MPR_{pp} \cdot fpd_{pp,dd} + \sum_{pp} MPP_{pp} \cdot fpd_{pp,dd}$$

Minimum nutritional levels and Maximum nutritional supply are specified for diet components subsets different for ruminents and monograstric animals

Farm Account

Farm account includes those terms recorded in RICA, which include a number of VARIABLE costs and revenues, depending on activity size.

Gross income from products sold (VIP) includes both those from crops (including straw) and livestock are deduced from market prices (ppp):

$$VIP_{pp} \equiv MPS_{pp} \cdot ppp_{pp}$$

Variable costs depend on unitary costs:

TECHNICAL INPUTS: seeds (pcs), water (pcw), chemicals (pch), veterinary chemicals (pcz), straw for stables (pc2)

LABOUR: transformation (pct), manpower (pcl), machinery (pcm), energy - including fuel (pce), third party (pc3)

SERVICES: ensurances (vce), organic certification (vco), commercialisation (vcc)

For crops (VCC) and livestock (VZT) those costs are given by:

$$VCC_{cc} = SCC_{cc} \cdot (pcs_{cc} + pcw_{cc} + pch_{cc} + pct_{cc} + pcl_{cc} + pcm_{cc} + pce_{cc} + pc3_{cc})$$

$$VZT_{zt} = SZT_{zt} \cdot (pc2_{zt} + pcw_{zt} + pcz_{zt} + pct_{zt} + pcl_{zt} + pcm_{zt} + pce_{zt} + pc3_{zt})$$

Costs of purchased fertilizers and feedstock are taken into account separately by means of prices of fertizers (pcf) and purchase feedstock (pcp):

$$VCF_{ff} \equiv MFP_{ff} \cdot pcf_{ff}$$

$$VCZ_{pp} \equiv MPP_{pp} \cdot pcp_{pp}$$
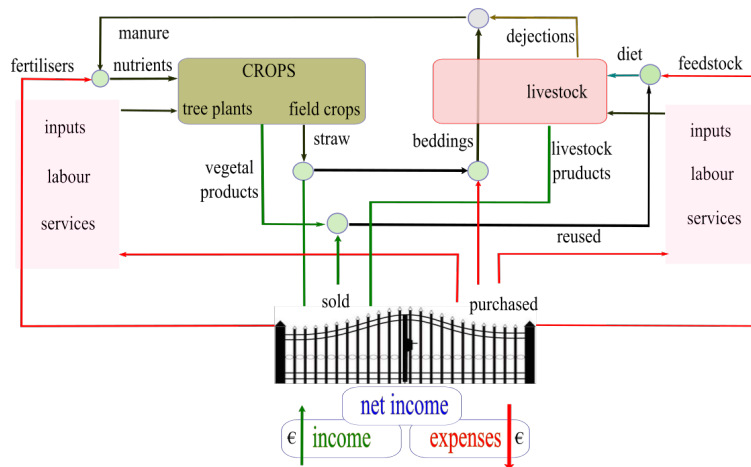
The Net Revenue (VNI) is so given by:

$$VNI = \sum_{pp} VIP_{pp} - \sum_{cc} VCC_{cc} - \sum_{ff} VCF_{ff} - \sum_{zt} VCZ_{zt}$$

Objective function is finally given by VNI of a number of years, as to costs and prices are applied taxes:

$$Z \equiv \sum_{aa} VNI_{aa}$$

MAD flow-chart

Parameters may also be seen in a flow-chart as circles oriented to change the meaning of flowing information therefore operating as transducers.

3   Architecture

Modules

- **MAD** is the name of a launcher which, invoked with different command-line parameters, is responsible to call other modules following the scheme of figure A1. A former conversion from RICA DB to text tables which can be directly imported from MAD has been made with an external ad-hoc procedure, which also prepares the snippets required to MAD for specfic table reading. Main Modules are:

- **MAD-rica** is used to read-in the full Italian FADN DataBase named RICA in the easily-readable intermediate GAMS file (MAD-rica.goo): it is used in a preliminary step, which has to be run only after a RICA update; it is run using the option –run=RICA

- **MAD-core** is a common code aimed at preparing a list of tables based on user-set filters, having two purposes

  - selecting farms to build technical parameters: it is pursued using option –run=PAR which will end preparing an intermediate GAMS file (MAD-par.goo) with technical parameters

  - selecting farms for optimisation purposes: it is pursued using the option –run=SEL which will end preparing a set of TXT tables (ready to be included) with the information on working farms; the same tables can pre prepared with a text or spreadsheet editor, as well as by a network service

- **MAD-opt** is the real MAD model: collecting technical parameters from MAD-par.goo, runs optimisation, invoke post-processing

modules (see MAD add-ons), and print-out results; again output text file can be managed by the server to deploy results to a client.
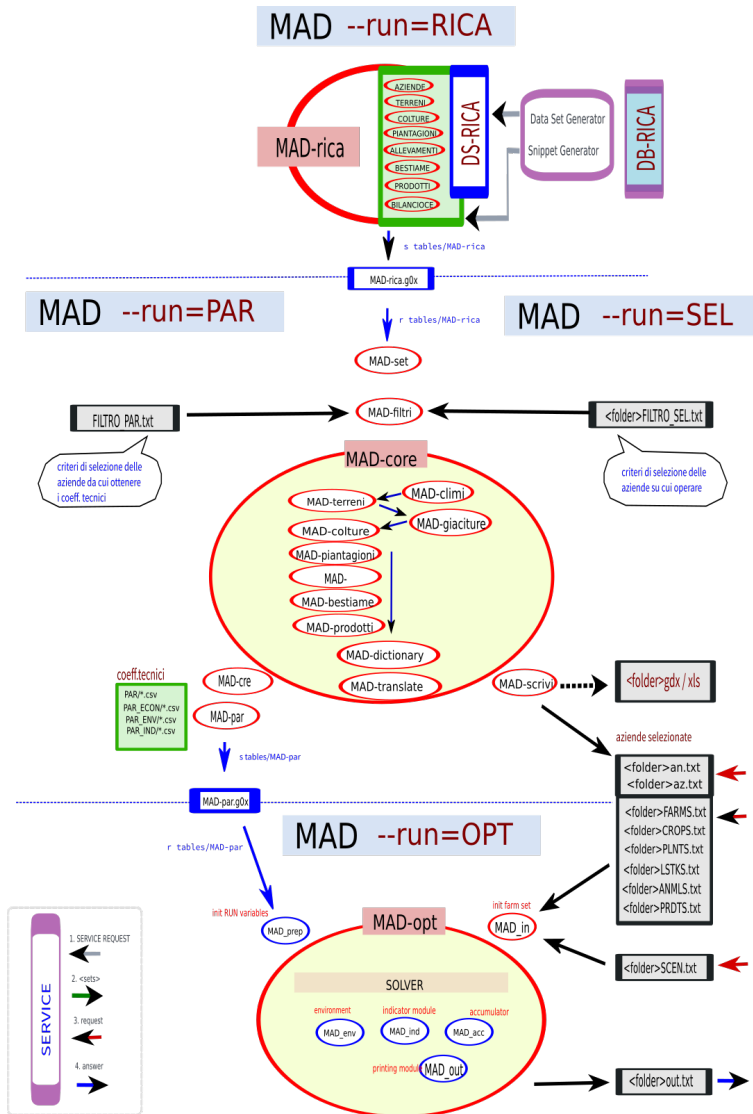
4 Operative modes

MAD ha two base mode of operation, one directed to base running procedures, as described above, and one to address optimisation itself.

1. Main Modes

–run=RICA to run MAD-rica, therefore to re-read RICA Data-Base (already prepared with an external procedure)

–run=PAR to prepare technical parameters both from RICA and
   OutSourced: it uses FILTRI_SEL

–run=SEL to select RICA farms: it uses FILTRI_SEL

–run=OPT <options> to run optimisation

MAD operational modes

2. Optimisation Options

MAD can be runned with different options, each aimed at selecting
different constraints:

–crop

   =0 - NO CHANGE TO SURFACES (USE PRESENT CROPS
      ONLY)
   =1 - OPTIMISE SURFACE ASSET USING CURRENT CROPS
      ONLY
   =2 - FIND BEST SET of ROTATIONS ALLOWED in FARM's CLI
      x GIA INCLUDING CURRENT CROPS
   =3 - FIND BEST SET of ROTATIONS ALLOWED in FARM's CLI
      x GIA (CROP ARE CHOSEN IN RE)
   =4 - FIND BEST CROP

–norm (subordinate to CROP =2,3)

   =1 - 1 supercrop: 1 crop - ONE CROP FOR REGION
   =2 - 1 supercrop: n crops - MORE CROPs FOR REGION

–lstk

   =0 - LIVESTOCK size is FIXED
   =1 - LIVESTOCK size can change (mainly REDUCED)

–rent

   =0 - NO RENTAL ALLOWED
   =1 - RENTAL ALLOWED

–fbio forcing the selected farm to adopt organic (=s) or conventional
   (=n) yield, costs and prices

–biog inclusion of biogas plant (see PhD Thesys - R.Malagnino -
   UNIBO-STAAA 2016)

–terr adopt close-cycle reuse of products at regional level (under
   validation)

–irri inclusion of irrigation (work in progress)

3. General purpose Options

–debug=yes[no] is used to activate parameter & variable display

–fileGDX=<name> to print a GDX output file

–fileXLS=<name> to generate a XLS output file