Cost benefit analysis of CBPP control strategies at herd level in a zone of Ethiopia

I- **Introduction** : general presentation of the thesis

II- **Cost Benefit analysis** : methods and steps

III- **Indicators and required data**

IV- **Modeling methods**

I- General presentation of the thesis

- **Associated laboratory**: ILRI / CIRAD-EMVT
- **University** : Lyon I (France)
- Interdisciplinary Doctorate Unit of Science and Health
- **MSc** : Analysis Methods of Health Systems (Pr Duru) : 1998-99
- **Thesis Comity** :
  - M.O. Carrere (Pr. Health Economics, Lyon I)
  - B. Faye (CIRAD-EMVT, PPA)
  - B. Dufour (AFSSA, Paris)
  - Ch. Ducrot (INRA, Clermont-Ferrand)

CBPP : Contagious Bovine PleuroPneumonia

- **Pathogen** : *Mycoplasma mycoides sp mycoides SC*
- **Affected species** : bovine only
- **Transmission** : direct contact
- **Distribution** : Africa, Asia, Europe (Portugal)
- **Symptoms** : acute to chronical pleuropneumonia with cough, fast breathing, fever, emaciation…
- **Treatment** : Antibiotic is possible but not efficient and not recommended
- **Vaccination** : widely used but low protection (40% protection at the first shoot)
- **Importance** : CBPP is becoming the major contagious disease of cattle in Africa (before rinderpest)

Cost-benefit analysis...

- **Objectives** :

  1- Compare alternative disease control strategies in terms of economic or financial effects

  2- Choice of appropriate strategies

- **Level of analysis** : from herd to national level ,

  the herd level is the choice for this thesis

- **Extended time horizon**

- **Technical characteristics, decision criteria and steps** : see further

… of CBPP control strategies at herd level…

- **1st Strategy**: reference strategy: treatment of sick animals, as practised by the farmers
- **2nd Strategy**: single vaccination of the herd (as practised by Ethiopian veterinary services) : 1 single shot for 5 years
- **3rd Strategy**: successive vaccinations: protocol recommended by OIE : 5 shots the first 3 years
- **4th Strategy?** : association with non medical strategies : isolation of sick animal, slaughtering

...in a zone of Ethiopia

- West Wollega Zone : Oromo Region, 500 km to the West from Addis Ababa
- Midlands (1300-2000m), Traditional mixed crop-livestock farming system
- Outbreaks of CBPP reported by authorities since 1992
- Longitudinal survey (follow-up) implemented in April 2000 (cf ATP)

II- Steps of Cost-Benefit Analysis in Animal health economics

- **1st Step** : Specification of technical characteristics

- **2nd step** :Specification of the flow of costs and benefits :
  a- Listing, description and calculation of costs and benefits for each strategy in physical (quantitative) terms
  b- Assessment of the effect of each control strategy

- **3rd step** : Monetary valuation of costs and benefits
- **4th step** : Choice of an appropriate discount rate
- **5th step** : Cost and Benefit comparison, specification of decision criteria : NPV, IRR, BCR
- **6th step** : sensitivity analysis

CBA : 1st Step
Technical characteristics

- **Economic level of analysis** : Herd level
- **Point of view** :farmers only; the costs of treatments and vaccination are supposed to be covered by farmers ("cost recovery" policy)
- **Choice of time horizon** : 5 years (10 years?)
- **Control strategies to be compared** : 4 strategies (above-mentioned)

CBA : 2nd step
a- Listing and calculation of types of costs and benefits in physical terms

- Costs (to implement strategies)

- Strategy 1 (treatment of sick animals):

cost of treatments : sale cost of drug X number of animals treated,

transport costs (time, labour…)

- Strategies 2 and 3 (vaccination):

cost of vaccination (cost recovery policy) : sale cost of vaccine unit X number of animals vaccinated,

transport costs, cost of treatments

- Strategy 4 : in case of slaughtering of animals : opportunity cost of dead animals

CBA : 2nd step
a- Listing and calculation of types of costs and benefits in physical terms

- **Benefits :** Additional benefits, due to a strategy, in terms of animal production at herd level

- Animal productions in West Wollega

1- draught power,
2- milk production,
3- manure,
4- meat, hide and skins,
5- numeric production (fertility, offtake)

- Calculation of benefits:

Depend on the size and composition (oxen, cows…) of the herd and individual productions.

CBA : 2nd step
b- Assessment of the effect of each control strategy

An intra-herd epidemiological model will simulate the effect of each control strategy on the spread of CBPP within the herd.

1- Strategy with treatment of sick animals :

The field survey under real conditions will allow to assess the effect of CBPP and will provide data for modeling

2- Strategy with single vaccination (first year):

Same modeling but with 40 % individual protection according to experimental results (CIRAD-EMVT)

3- Strategy with successive vaccinations : supposed to be 100% protective after 1 year (2nd vaccination), equivalent to a herd without disease.

CBA : 3rd step
Monetary valuation of costs and benefits

- Costs:

  - Unit cost of treatment or vaccine dose (known from on-farm surveys, vet services and NVI), service cost?

  - Cost of transport (labour)

- Benefits:

  - Market-price (and its seasonal variation) of animal productions (known from on-farm surveys)

CBA : 4th step
Choice of an appropriate discount rate

Discount rate : r

$$PV = \frac{X_t}{(1 + r)^t}$$

- Literature review
- Sensitivity analysis
- **To be discussed together!!!**

CBA : 5th step
Cost and Benefit comparison, specification of decision criteria

- NPV = $PV_b - PV_c$
- BCR = PV_b / PV_c
- IRR = value of r for which NPV = 0
- Acceptability of a strategy :

NPV $\geq$ 0 BCR $\geq$ 1 IRR $\geq$ usual r

CBA : 6th step sensitivity analysis

- **Principle :** to conduct the analysis varying values of parameters for which uncertainty is high.
- **Parameters with uncertain values :**

  - discount rate
  - strategies efficiency (vaccine protection…)
  - farmers practises / behaviour (offtake rate…)
  - epidemiological parameters? Animal production values??? ⇒ results of surveys

- **Use of the epidemiological model to carry out sensitivity analysis**

III- **Indicators and required data**

- **INDICATOR : Annual average Individual Gross Margin (IGMij) and Herd Gross Margin (HGM)**

- **Animal productions ⇒ sex/production categories i**
- **Epidemiological status ⇒ epidemiological categories j**

- **Epidemio-production categories ij of animals**

Animal productions

- **Animal productions in West Wollega**:

  1- Draught power,

  2- Milk production,

  3- Manure,

  4- Meat and skin

  5- (Numeric production : fertility, offtake)

- **Sex/production categories i :**

Oxen : draught power, manure, meat and skin, offtake

Cows : Milk production, manure, meat and skin, (numeric production), offtake

Heifers and bulls: manure, calves : manure.

Epidemiological categories j

- Depend on the epidemiological status of individuals

- Categories j :
  - Status 1 (R') ----------**Calves**
  - Status 2 (S, E and Ich, Rch)----**Normal adults**
  - Status 3 (Icl and Rcl)----------**Sick adults**
  - Status 4 (dead)----------**Dead adults**

Epidemio-production categories ij of animals

i / j	Calf	Cow	Heifer	Ox	Bull
Calf	11	X	X	X	X
Normal adult	X	22	32	42	54
Sick adult	X	23	33	43	53
Dead adult	X	24	34	44	54

Annual average Individual Gross Margin (IGM) and Herd Gross Margin (HGM)

- IGMij = Rij - Cij

  Rij = annual revenues from animal productions (consummed or sold) for each epidemio-production category ij

  Cij = annual costs of individual production factors (except costs of CBPP control)

- IGMij (t)= discounted IGMij (for year t)
- HGM(t) = $\sum_{(ij)}$ IGMij(t)

Calculation of Ri
1- Formula

- $Rij = Tij + Mij + Fij + Oij$

- Tij = annual revenues from animal traction (and other works) from animal of category ij
- Mij = annual revenues from milk production

- Fij = annual revenues from manure (faeces) production
- Oij = average annual revenues from offtake (i.e. sold or slaughtered at farm)

Calculation of Ri: 2- Animal production data

- **Draught power (T):** the production unit is the "half-day of work" : 50 oxen involved in the survey (2O CBPPfree farms + 10 infected farms)

- **Individual annual milk production (M):** unit is litre of milk ⇒ measurement of quantity milked and sucked by calf (60-70 cows in same farms)

- **Manure (F):** faeces production (kg) and N equivalence with chemical fertilisers (literature)
- **Offtake (O):** animal offtake (sold and slaughtered) rate

Calculation of Ri: 3- Economic data

- **Draught power price:** oxen are rented out in the surveyed area : the average price of one half-day of rent will be measured

- **Milk price :** milk is not sold in Wwollega but butter is : we will measure the price of kg of butter sold from the farm (throughout the year),

- **Manure price:** cost of chemical fertiliser?
- **Offtake :** sale price of animals from farm

Calculation of Ci : Production factors

- Veterinary treatments (except CBPP): amount of treatments or care and their cost will be known from the survey

- Animal feeding :

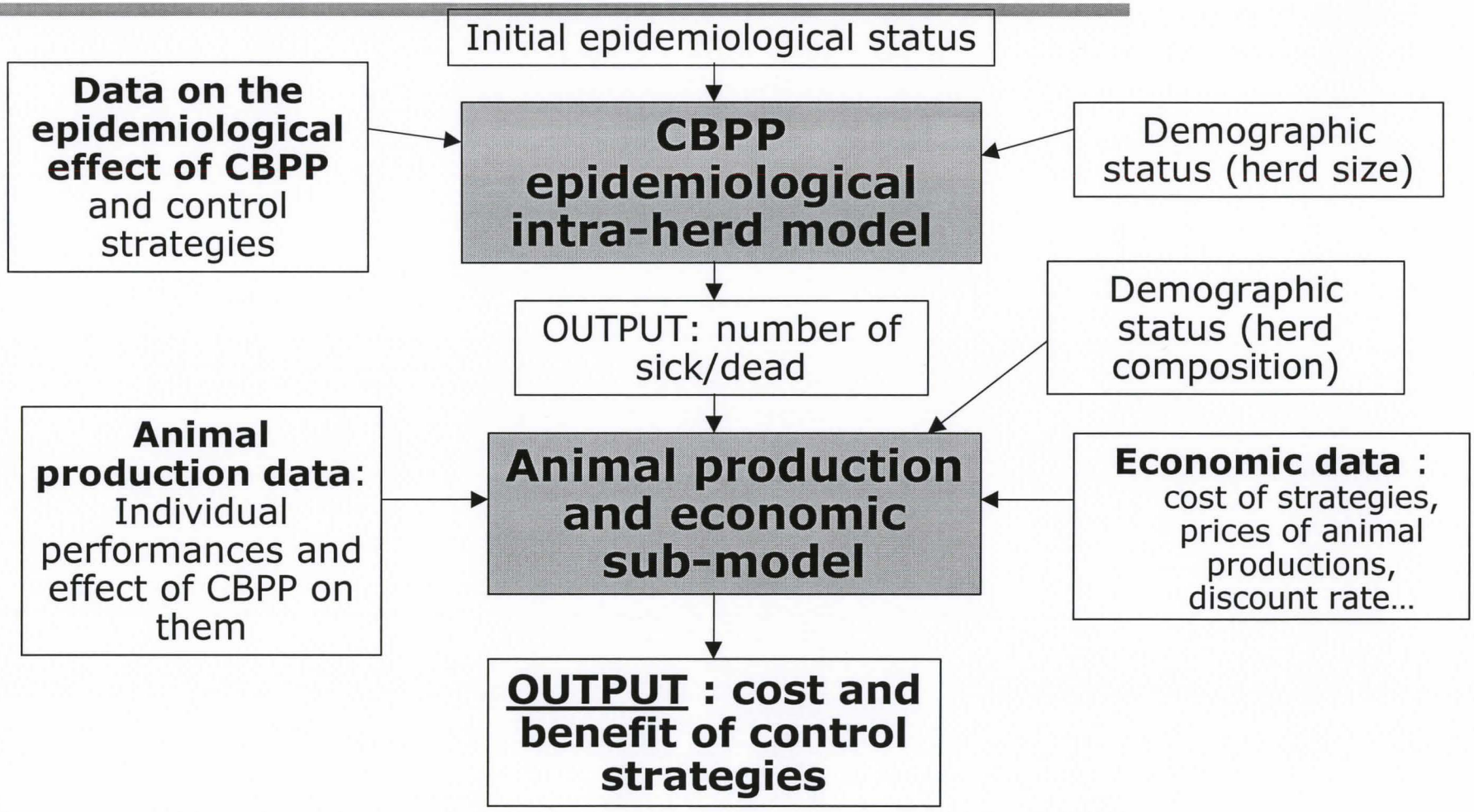
  Feeding of animals on crop residues

  Feeding of oxen during working time with crops

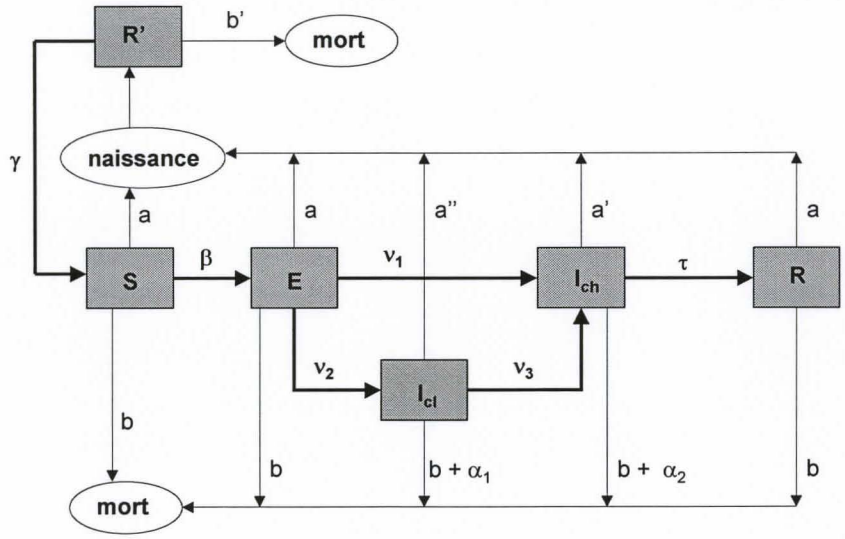
- Others : human labour not taken into account

IV- Modeling methods

Modeling the cost and benefit of control strategies using various data



The intra-herd epidemiological model developed at CIRAD-EMVT



- Simulation model
- Deterministic (fixed transition coefficients)
- Compartment model
- SEIR scheme :

  partition of population in categories : Susceptible, Exposed, Infected, Recovered
- I is divided into 2 groups : clinical and chronical cases (Icl and Ich)

Outputs from the epidemiological intra-herd model

- Initial condition (T0) :
  - Strategy x
  - Herd population (S and R') at T0 (i.e.20 animals)
  - Initial epidemiological status : entrance of 1 sick animal at T0
- After simulation :

Population at t in each category

S, E, Icl, Ich, R (and dead)

The Animal production and economic sub-model : INPUTS

- **Herd composition (in terms of sex/production categories i):**

  calves(1) , cows(2), heifers(3), oxen(4), bulls(5)

- **Population distribution for CBPP status (j) from t-1 to t after epidemio simulation:**

  Status 1 (R') ----------**Calves**
  Status 2 (S, E and Ich, Rch)------**Normal adults**
  Status 3 (Icl and Rcl)----------**Sick adults**
  Status 4 (dead)----------**Dead adults**

- **Annual average Individual Gross Margin (IGMij) for each epidemio-production category ij**

Herd composition in terms of sex/production category and epidemiological status at time (t) after simulation of the intra-herd model (fiction)

	YOUNGS (20%)	ADULTS (80%)				Total
	Calves	Cows (37 %)	Heifers (19 %)	Oxen (25 %)	Bulls (19%)	
Status 1 : calf	4	X	X	X	X	4
Status 2 : normal adult	X	5,25	2,625	3,5	2,625	14
Status 3 : sick adult	X	0,75	0,375	0,5	0,375	2
Status 4 : Dead adult	X	0,375	0,1875	0,25	0,1875	1

Table of annual average Individual Gross Margin $IGM_{ij}(t)$ for each epidemio-production category ij

j \ i	Calf	Cow	Heifer	Ox	Bull
Calf	$IGM_{11}(t)$	X	X	X	X
Normal adult	X	$IGM_{22}(t)$	$IGM_{32}(t)$	$IGM_{42}(t)$	$IGM_{52}(t)$
Sick adult	X	$IGM_{23}(t)$	$IGM_{33}(t)$	$IGM_{43}(t)$	$IGM_{53}(t)$
Dead adult	X	$IGM_{24}(t)$	$IGM_{34}(t)$	$IGM_{44}(t)$	$IGM_{54}(t)$

OUTPUTS of the zootechnic and economic sub-model : the calculation of economic indicators (HGM, PVb)

- HGM(t) =

At t	Calves	Cows	Heifers	Oxen	Bulls
Status 1	4	X	X	X	X
Status 2	X	5,25	2,625	3,5	2,625
Status 3	X	0,75	0,375	0,5	0,375
Dead adult	X	0,375	0,1875	0,25	0,1875

X

j	Calf	Cow	Heifer	Ox	Bull
Calf	$IGM_{11}(t)$	X	X	X	X
Normal adult	X	$IGM_{22}(t)$	$IGM_{32}(t)$	$IGM_{42}(t)$	$IGM_{52}(t)$
Sick adult	X	$IGM_{23}(t)$	$IGM_{33}(t)$	$IGM_{43}(t)$	$IGM_{53}(t)$
Dead adult	X	$IGM_{24}(t)$	$IGM_{34}(t)$	$IGM_{44}(t)$	$IGM_{54}(t)$

- $HGM = \sum t\ HGM(t)$
- $PV_b = HGM_{(strategy\ x)} - HGM_{(strategy\ 1)}$