United Nations University
"advancing knowledge for human security and development"

INRAN

United Nations University
UNU-INRA
Institute for Natural Resources in Africa

Modeling agronomic and economic flux in a small watershed in Niger river basin : case of Kourani-Baria

UNU-INRA Visiting Scholars Program 2011

ADAM Mamadou

INRAN, Niger

www.inra.unu.edu

Outline of the presentation

- Introduction
- Problematic
- Objectives of the study
- State of art
- Methodology
- Results
- Discussion & conclusion

Introduction

- Problem of externalities in irrigated area (flooding, siltation)
- Irrigation schemes are deteriorating because of these externalities
- Technical solutions for these externalities are experimented but they are not done spontaneously
- Issue must be addressed at the scale of watershed

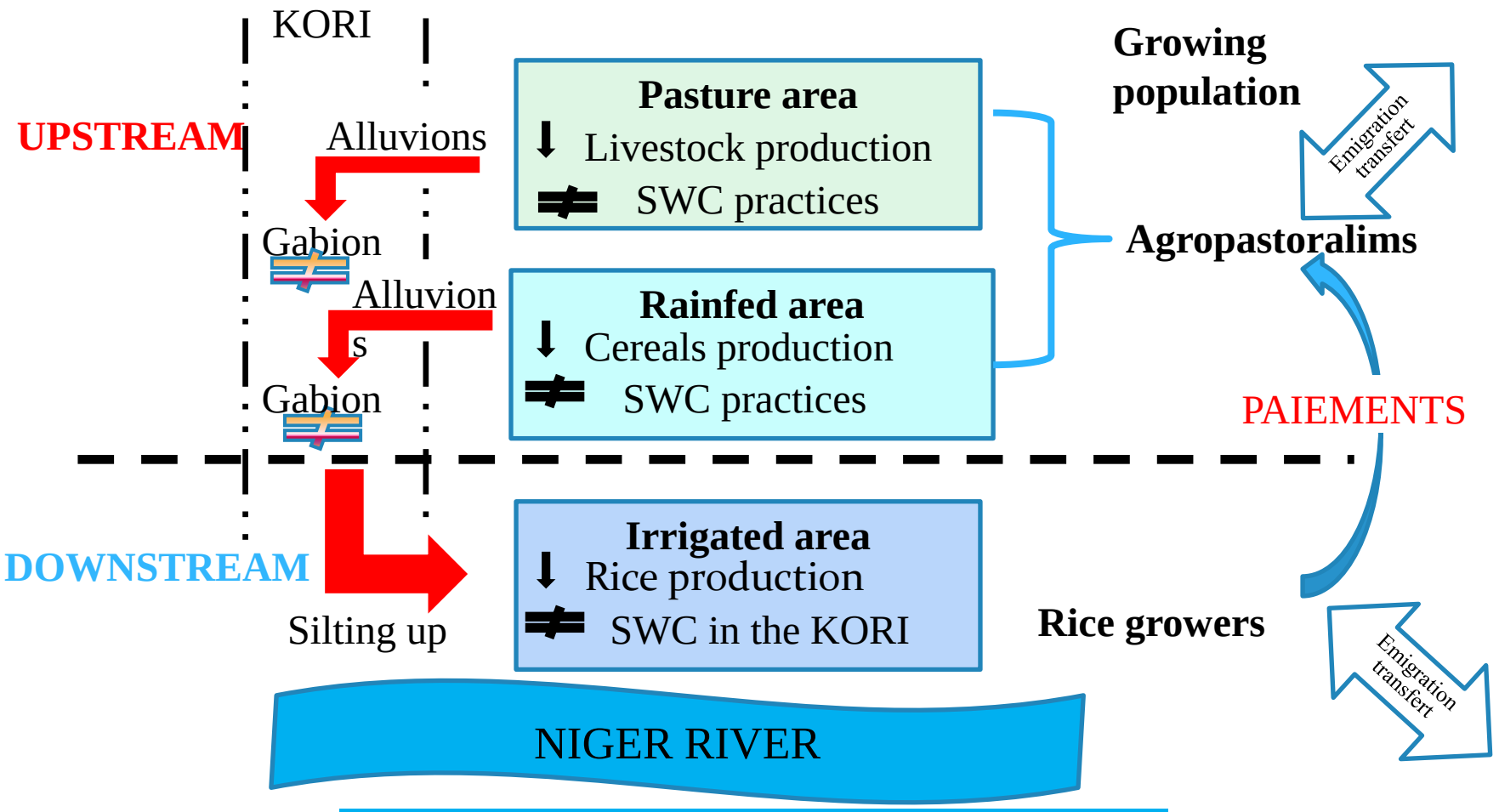
Problematic : Upstream (1/3)

- Agro-pastoralists, with maximum numbers of animals, trying to provide food for them and there animals,
  - ❖ Deteriorate the environment
    - Because of bad agricultural practices
    - Because of the tragedies of the commons
    - This situation require rules to limit numbers of animals and extension of slash and burn practices
  - ❖ create negative externalities
    - Erosion, silting, flooding and reduction cultivated area
    - to these externalities we can't apply Pigouvian tax
  - ❖ But agro pastoralist agree to reduce these externality
    - if a salary is given at rates revealed by experience
    - if they are paid at rates revealed by experience

Problematic: Downstream (2/3)

- Rice producer create a tradable rice surplus
  - but they are faced with agronomic and economic losses
    - The yield decrease
    - Rice production cost also increase
    - The irrigate area decrease
    - The irrigation schemes will be completely degrade
  - They are suffering for externalities coming from elsewhere
    - Again, these externalities, it s also impossible to use the pigouvian tax based on the polluter pays principle
    - But it possible to apply an indirect tax based on the beneficiaries pays principle
  - They want to reduce upstream negatives externalities
  - They are ready to pays upstream farmer to preserve their environment

Problematic : Watershed scheme (3/3)



Objectives of the study

- To assess PES tools at local scale
  - Identify the responsibility of those who are generating externalities
  - Assess the impact of those externalities on upstream and downstream activities
  - Predict the sustainability of a watershed
- To achieve this goals, a bioeconomic model is develop to simulate different scenarios

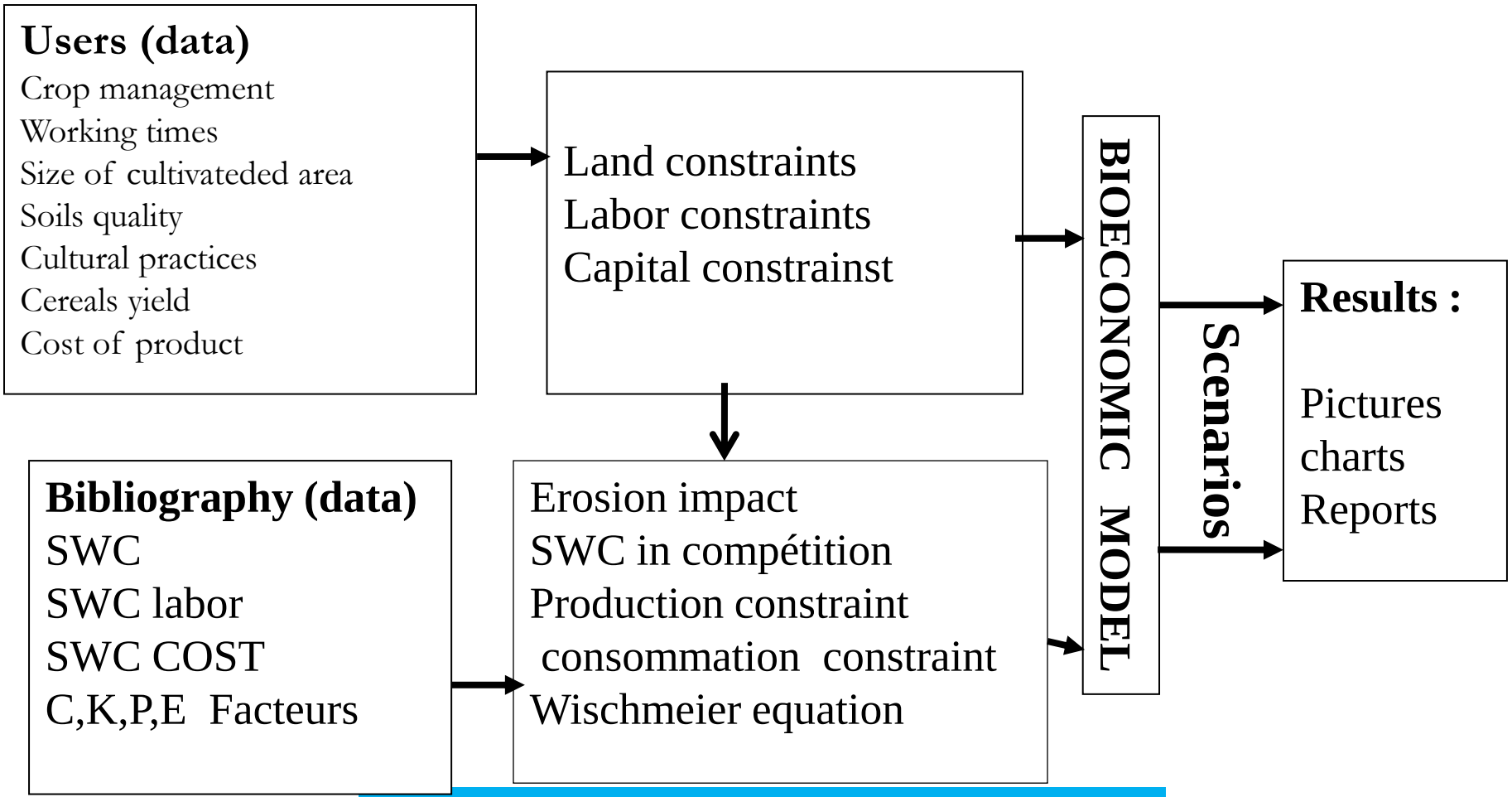
State of art

- PES tools began around 1980 (Perrings and Arriagada 2009),
  - mainly applied in developed countries (Porras, Grieg-Gran and Neves (2008), Perrings and Arriagada, 2009; FAO, 2007)
  - begin to take hold in developing countries (Grain to green in China, Costarica, etc.)
  - are not experimented in Africa
- most of the PES concern
  - water services at small scale of watershed (Vittel, Evian, California, etc.)
  - carbon sequestration services at a large scales
  - and biodiversity protection services at a large scales
- We didn't found an example for PES in agriculture where farmers pays other farmers to provide them an ES

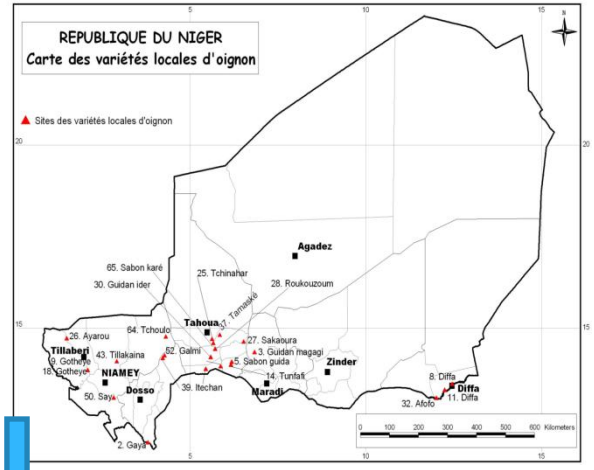
Methodology: Outline of model (1/5)

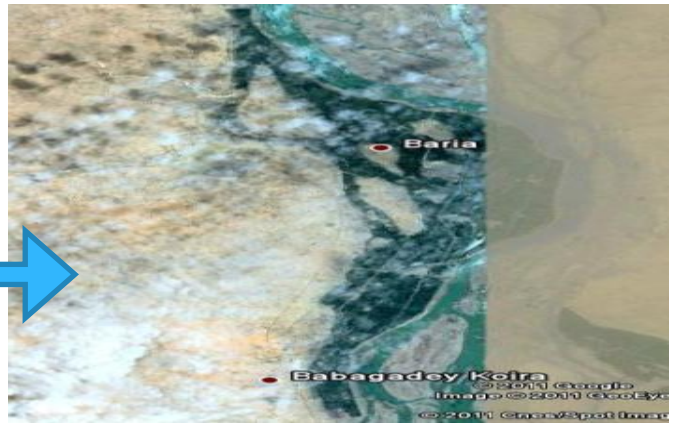
- Mathematical programming, using GAMS
- Upstream and Downstream are in interaction
- distinguish three groups of users, both upstream and downstream
- include the flow of agronomic interest
- include equation of erosion, sedimentation
- under constraints of production and consumption
- Production and consumption are non separable
- SWC are in competition
- Dynamic and recursive
- Maximization of monetary income

Methodology: Steps to build model (2/5)



Methodology: Study area (3/5)





Kourani Baria Watershed

- W Niger, 90 KM NW Niamey
- located at the right side of Niger river
- 15000 habitants
- 21 Villages
- 17000 ha
- Severe upstream erosion's

Irrigated area of watershed

- Total irrigated area are 750 ha and 69 3 ha are harnessing
- 1774 rice producers
- 2 Cooperatives KB1 ET KB2
- Downstream deteriorate by externalities (flooding and silting)

Methodology : Upstream model (4/5)

- Only agro-pastoralists uses all the resources of the watershed under various constraints

- Max ((Q(c)xPc + Q(e) Pa) + Surf(TSWC) x Sub(SWC) +rev Mig

- Under several constraint mainly land, labor, erosion capital, etc.

- Many scenarios are simulated (without subsidies, with subsidies)

Methodology : Downstream model (5/5)

- Only rice producers exploits all the resources of the watershed under various constraints
- Max ((Q (rz) x Prz + Q(e)Pa) – Surf (TSWC) x PES (TSWC))
- Under several constraint mainly land, labor, silting, Capital, etc.)
- Many scenarios are simulated (Without payement, with various amount of payment, 20 million, 25 billon, 30 etc.)

United Nations University
"advancing knowledge for human security and development"

United Nations University
UNU-INRA
Institute for Natural Resources in Africa

Some results

Some statistics about users behavior

Upstream model results

Dowstream model results

www.inra.unu.edu

Some statistics: Agro pastoralist behavior (1/2)

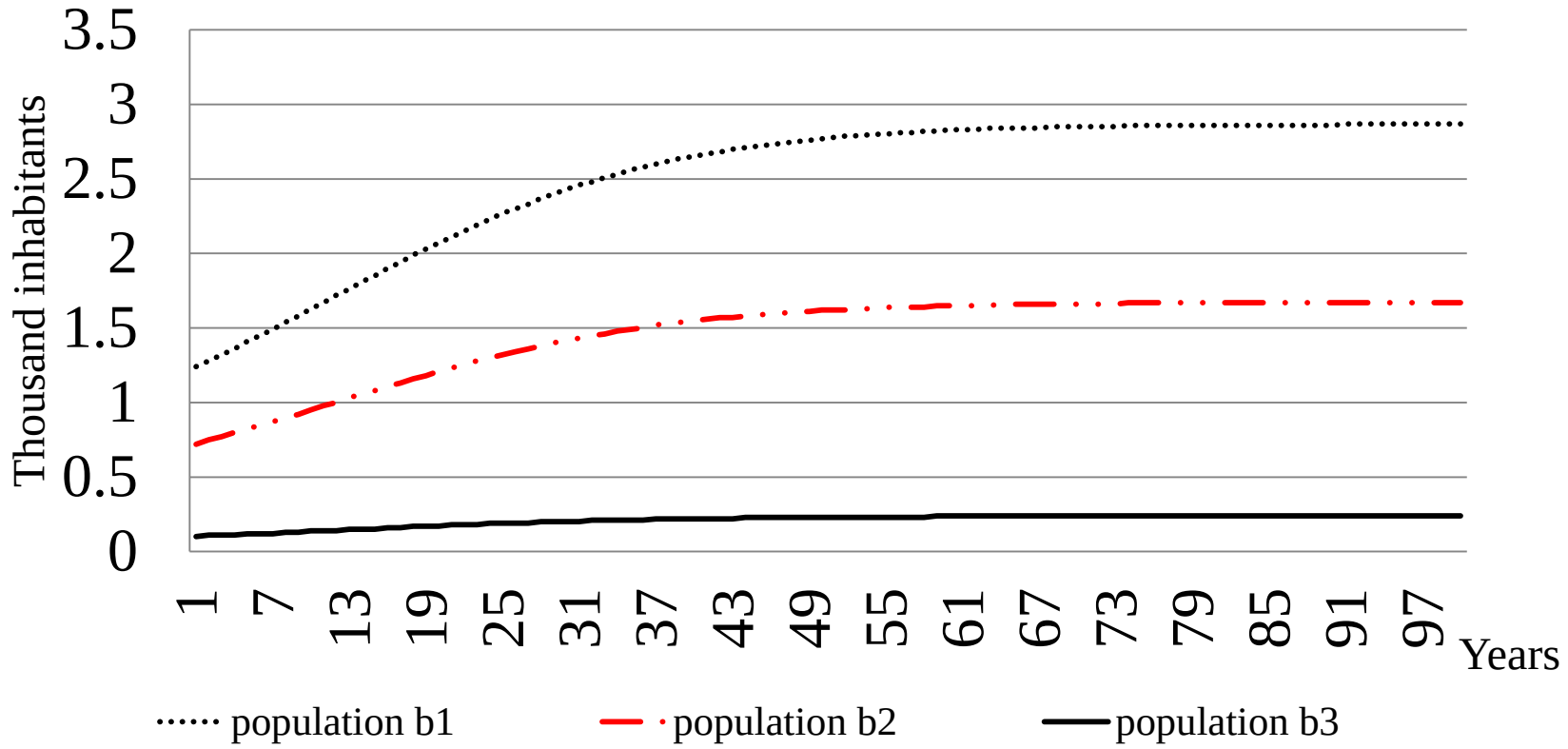
- 80% had a degraded land;
- 65% think that the main causes are their own farming practices;
- 43.75% have abandoned their fields because of bad cultural practices and runoff;
- 100% are willing to provide SWC services;
- View differ on the choice of kind of payment: 41.93% for cash payment and 48.38% for material payment;
- They need a means payment of **2,737** FCFA per workday to Realize SWC Techniques

Some statistics :Rice Producer behavior (2/2°

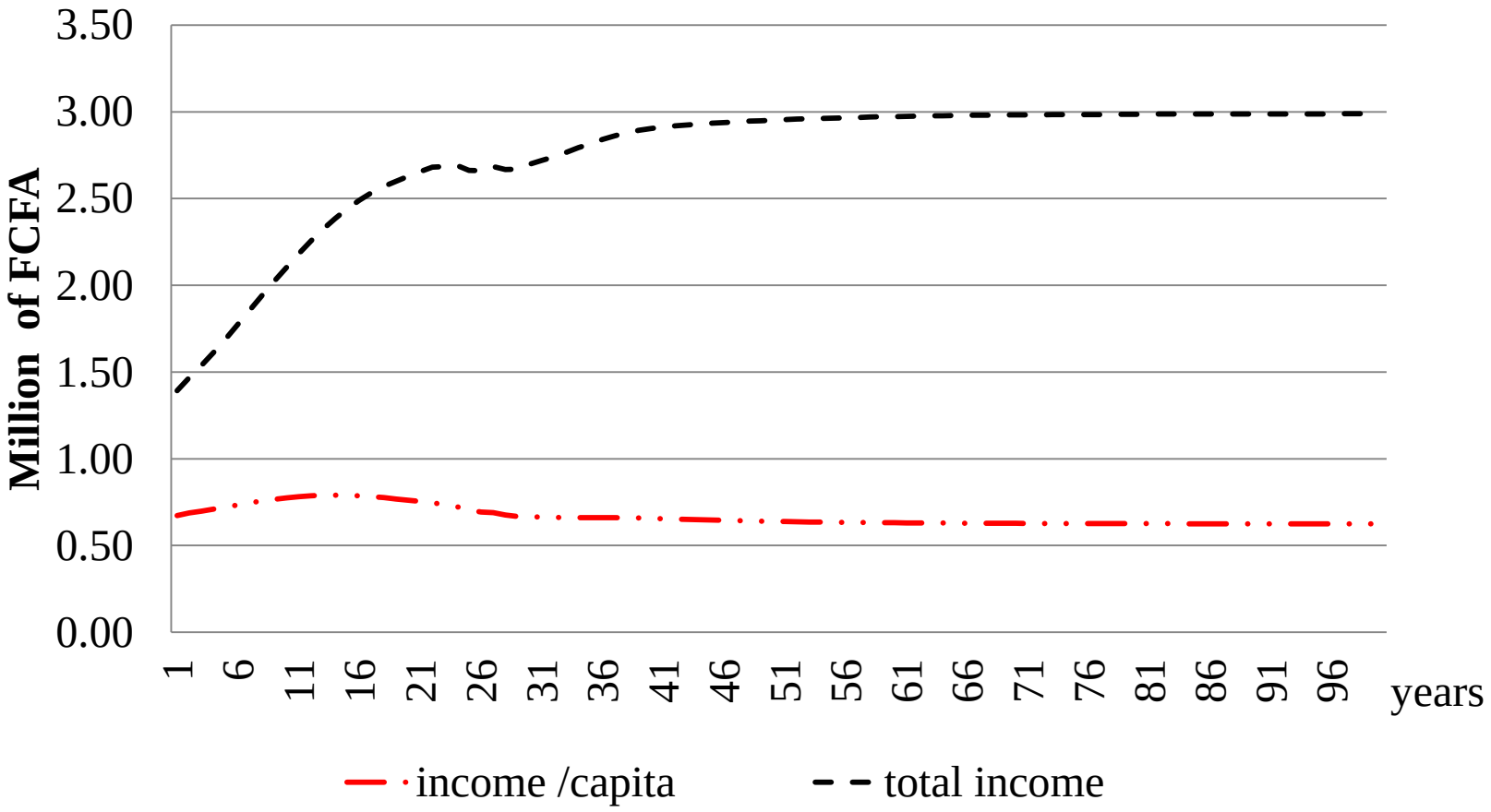
- 80% think that the irrigated perimeter is degraded and silting;
- They believe that irrigation infrastructure are deteriorate; and rice plots are lost and production costs are becoming higher;
- Over 80% are willing to pay for reducing silting;
- They can gives an average payment of **2842** FCFA / campaign by rice producer;
- They can contribute in physical payement

Upstream model results

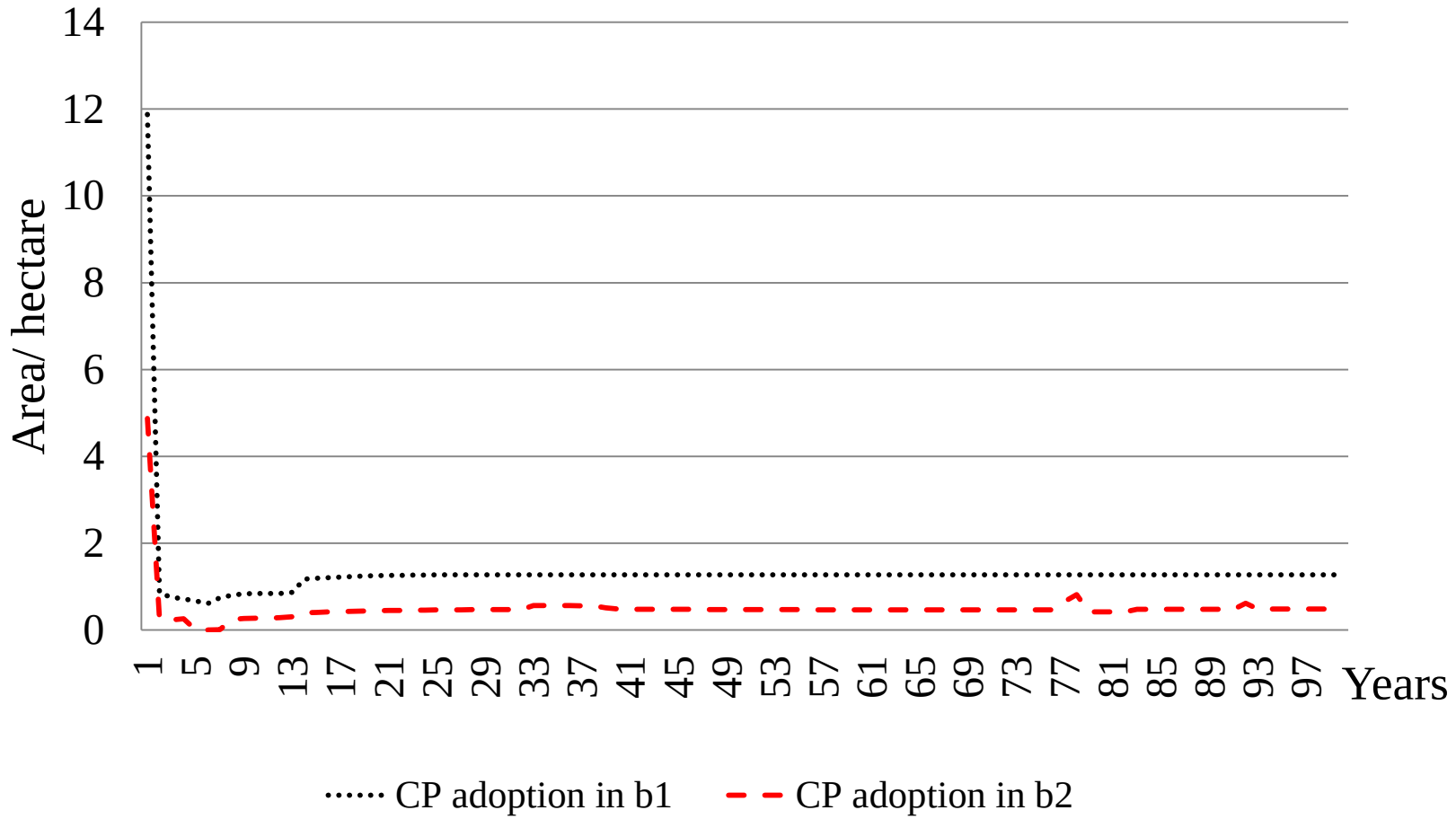
- Population growth



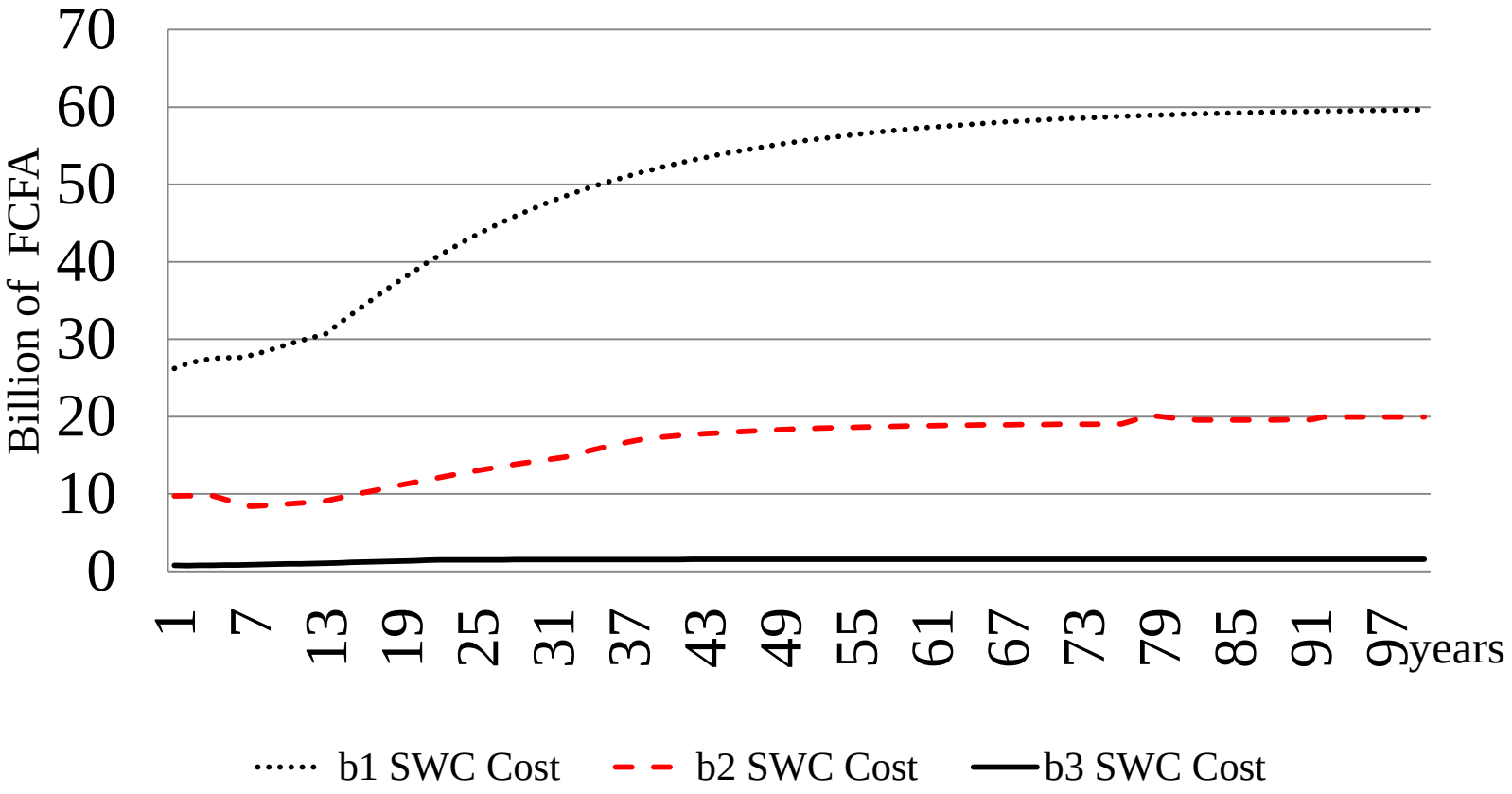
Income evolution



Evolution of SWC adoption



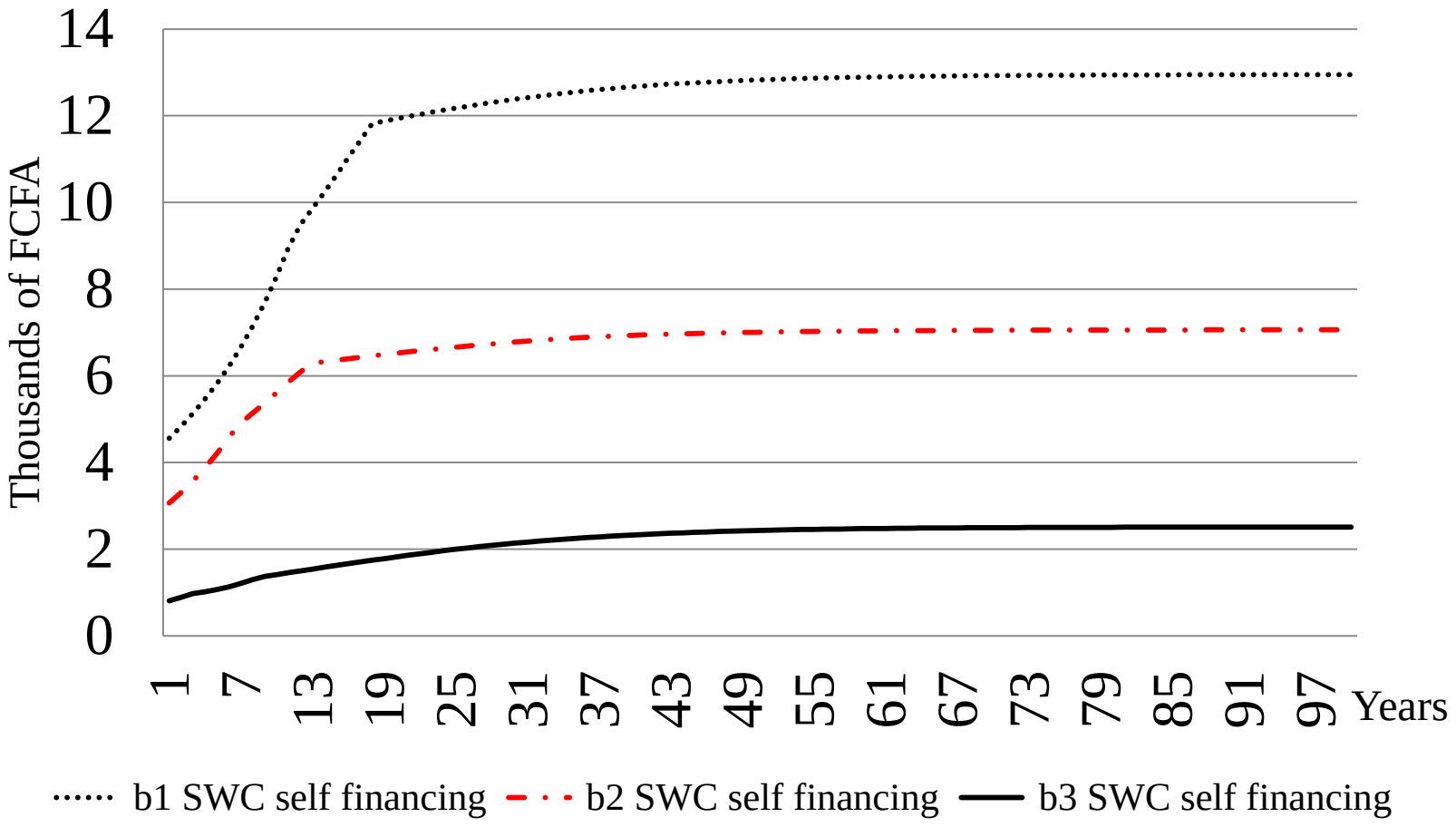
SWC cost evolution



United Nations University
"advancing knowledge for human security and development"

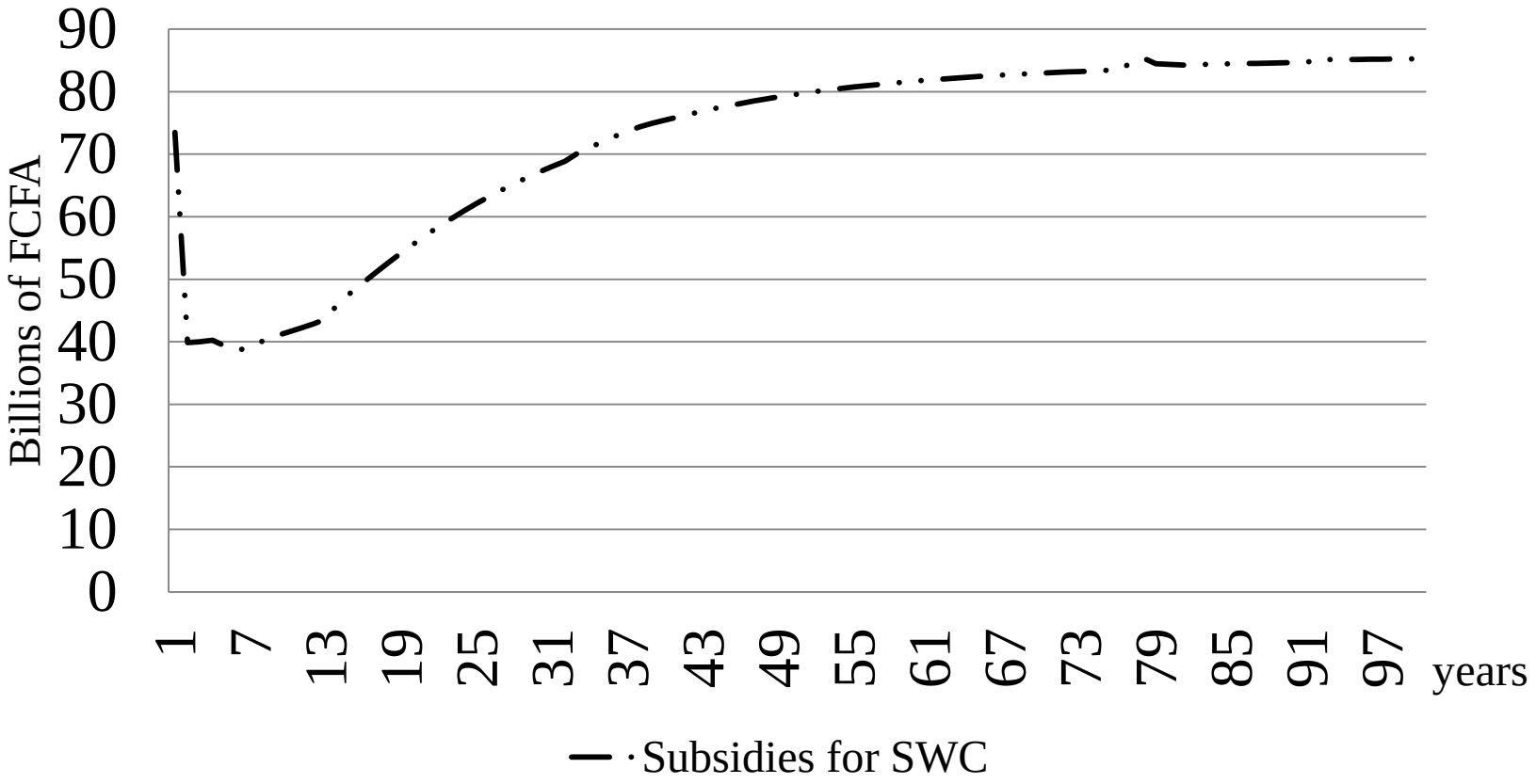
United Nations University
UNU-INRA
Institute for Natural Resources in Africa

SWC self financing



www.inra.unu.edu

Need subsidy for SWC

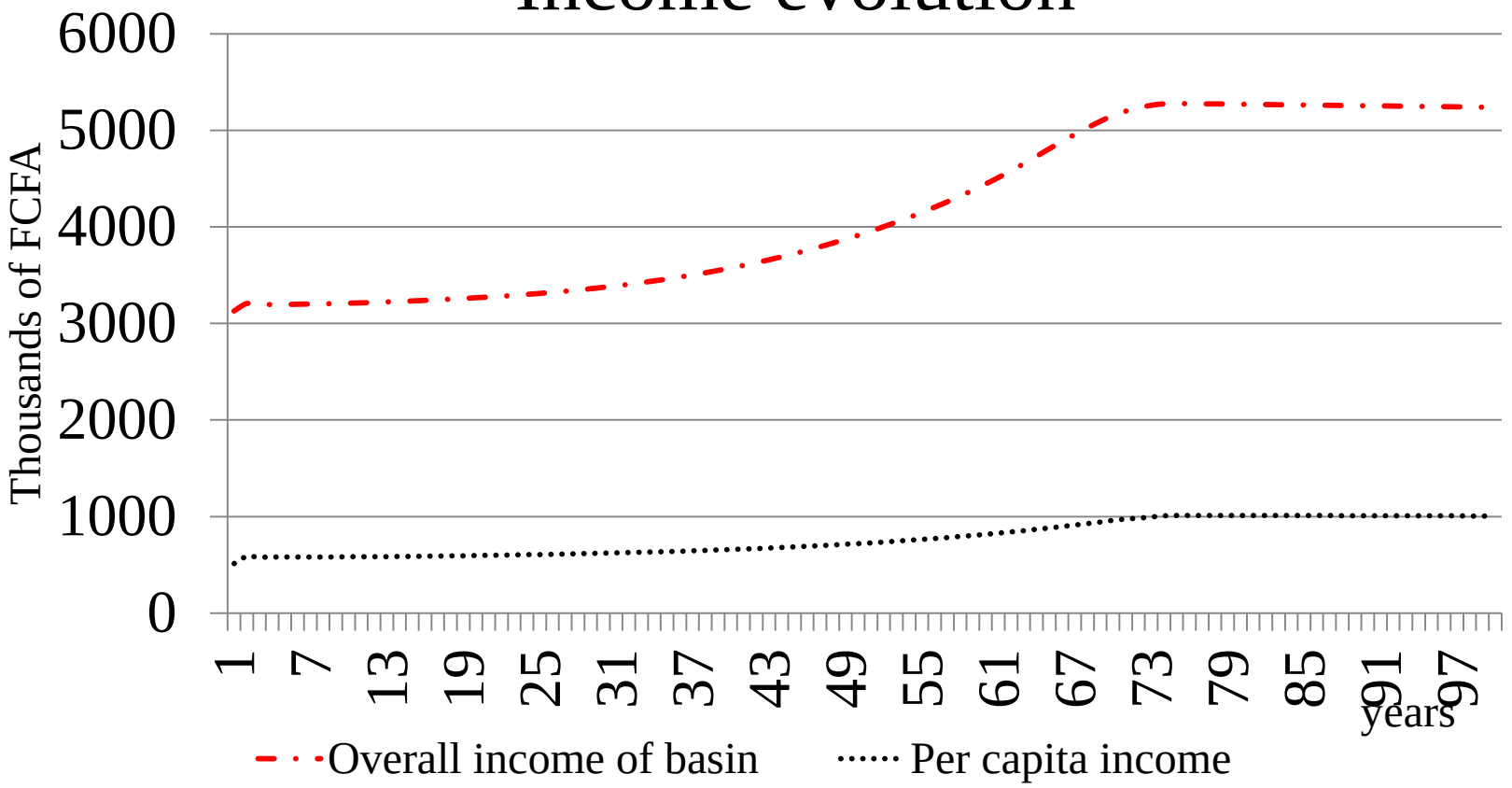


Upstream model Conclusion

- Agro pastoralist realization in their farm is not enough to reduce degradation and silting;
- Upstream agro-pastoralist need subsidies to achieve SWC in degraded land
  - When subsidies are low, SWC adoption are low, degradation is only slow down for only few years
  - When subsidies are high, SWC are well achieve and then irrigated areas are protected for so long time
- Is it possible to downstream rice producer to pay the subsidies ?
- Which amount of subsidies are reasonable for rice producer?

Downstream model results

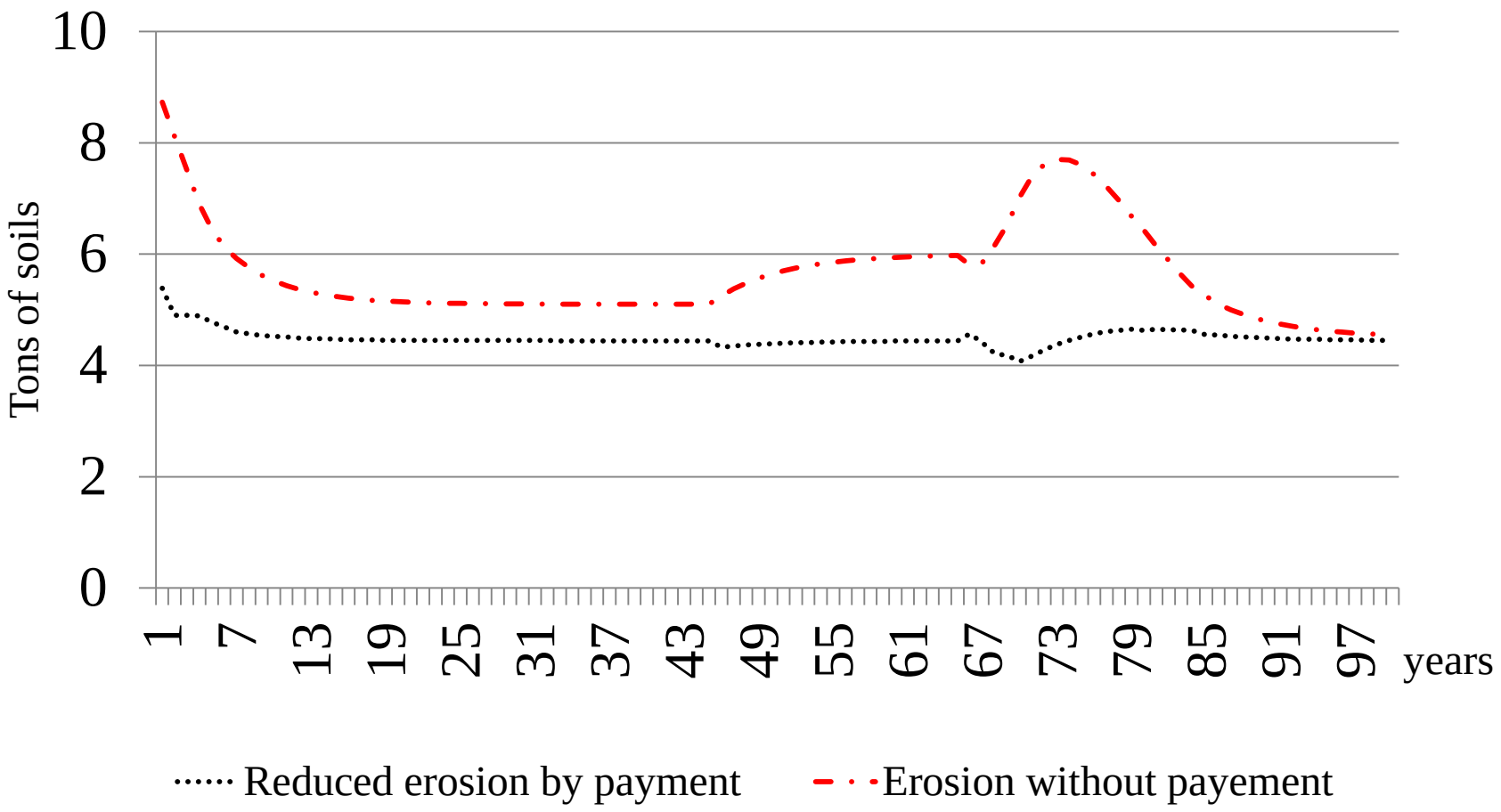
- Income evolution



United Nations University
"advancing knowledge for human security and development"

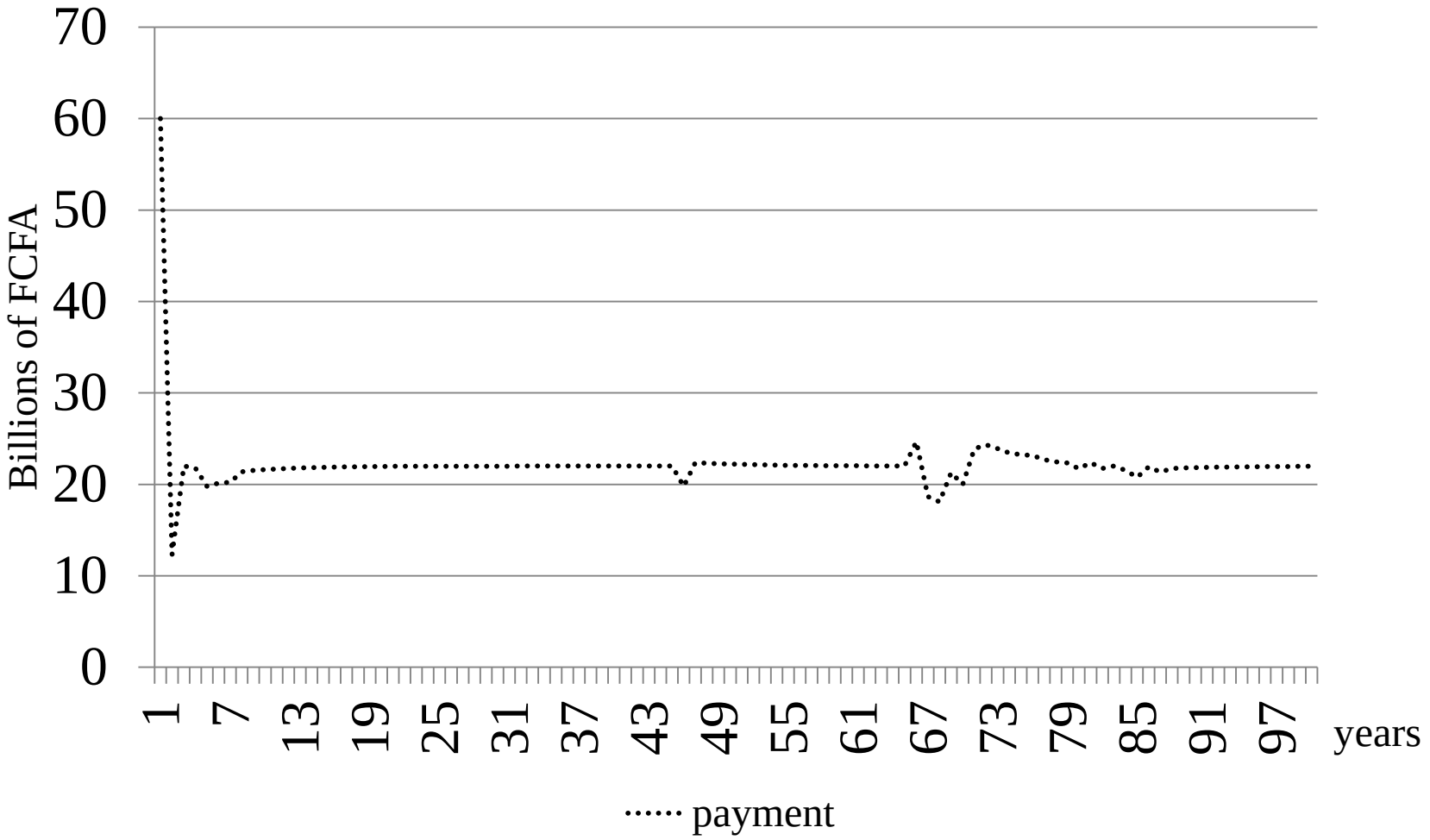
United Nations University
UNU-INRA
Institute for Natural Resources in Africa

Erosion comparaison



www.inra.unu.edu

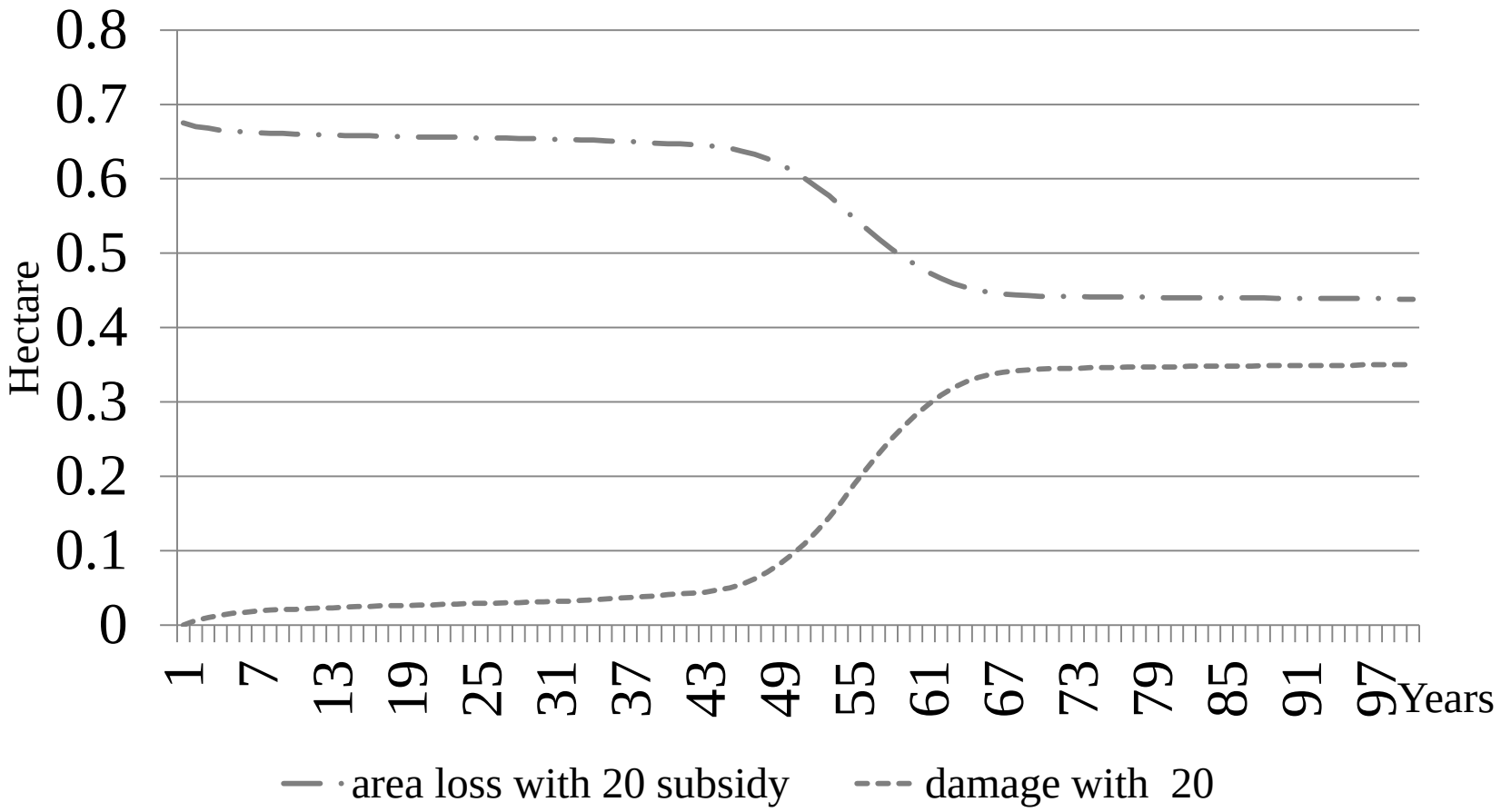
Payment


70
60
50
40
30
20
10
0
Billions of FCFA
1
7
13
19
25
31
37
43
49
55
61
67
73
79
85
91
97
years
payment

United Nations University
"advancing knowledge for human security and development"

United Nations University
UNU-INRA
Institute for Natural Resources in Africa

Initial state Without Upstream dommage

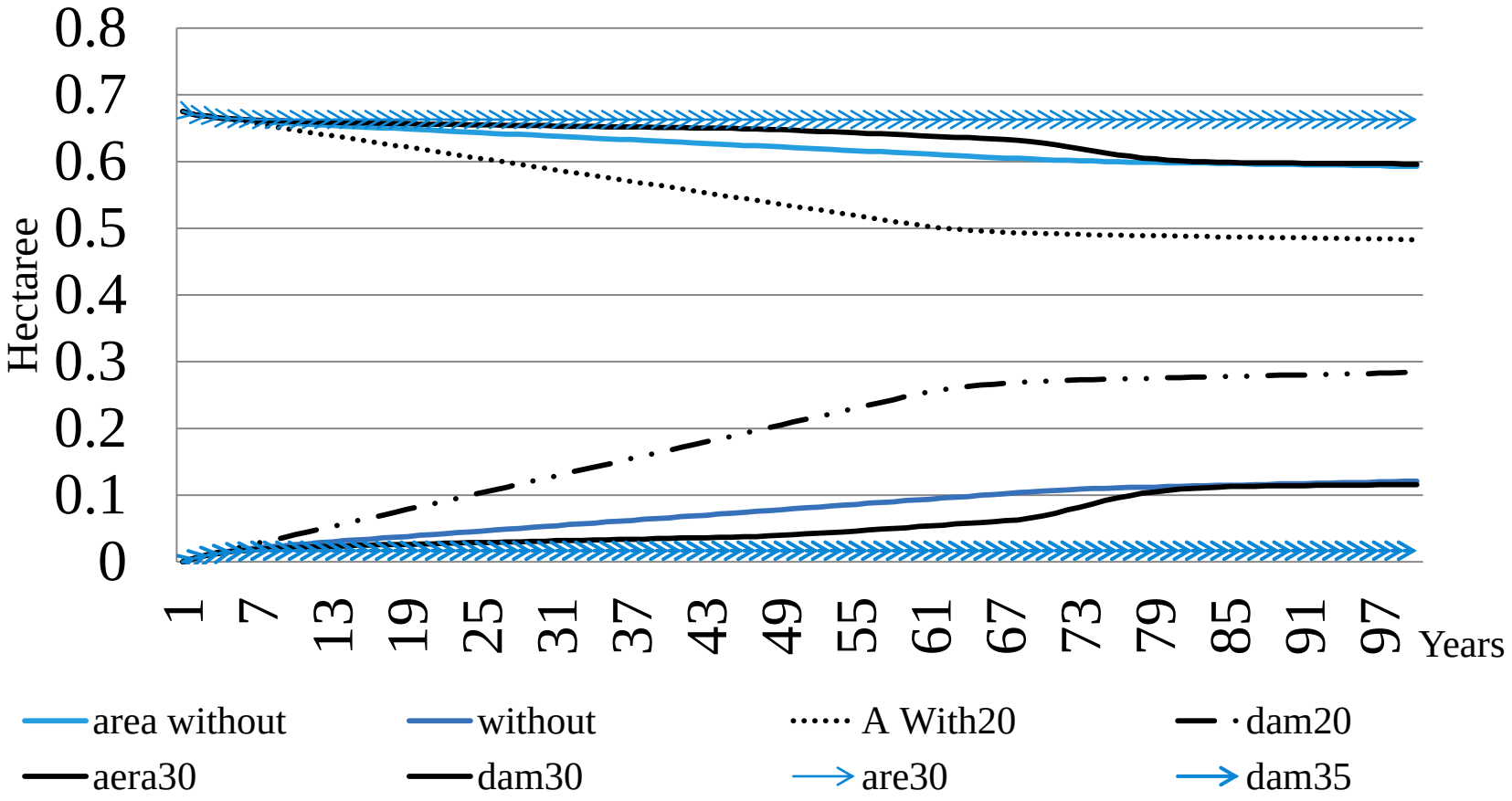


www.inra.unu.edu

United Nations University
"advancing knowledge for human security and development"

United Nations University
UNU-INRA
Institute for Natural Resources in Africa

Comparaison of differents rates of payements



www.inra.unu.edu

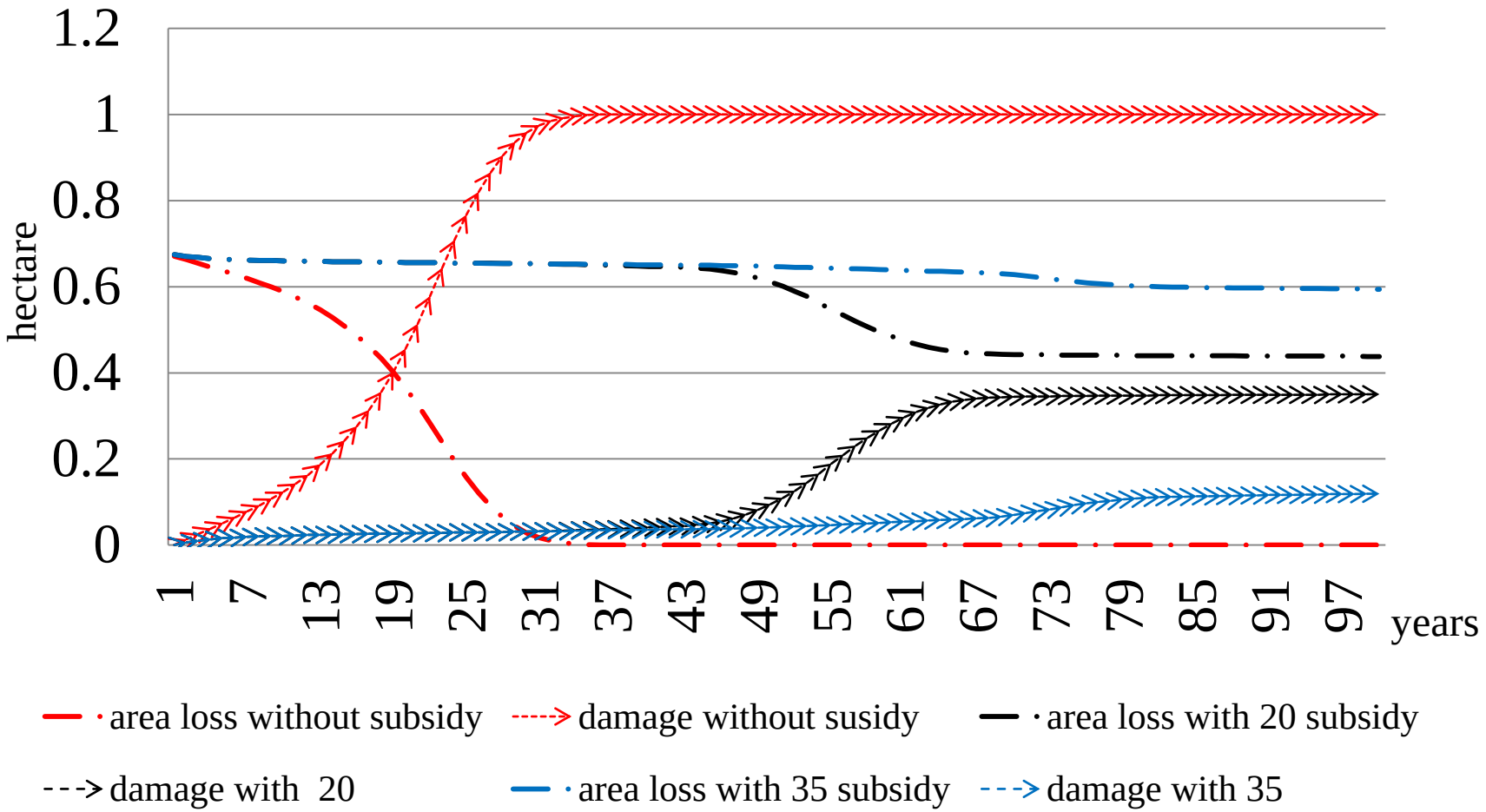
Downstream conclusion

- Realization of SWC techniques increase the sustainability of the irrigated area;
- Rice producers can finance the cost of realization of SWC techniques;
- The level of sustainability depends on the amount of the payment
  - When the payment amount is low, the duration of sustainability for irrigated area is too small
  - When the payment amount is high, the duration of sustainability for irrigated area is so long

United Nations University
"advancing knowledge for human security and development"

United Nations University
UNU-INRA
Institute for Natural Resources in Africa

Synthesis



www.inra.unu.edu

Discussion & conclusion

- Without adoption of SWC, the watershed will degraded
- Watershed resource management is not sustainable
- Profitable SWC techniques (cultural practices) are adopted by upstream agro pastoralist without subsidy
- Effective SWC techniques are adopted in degraded area only if payment are gives
- Agro pastoralists invest more in SWC techniques whether agricultural land is no longer available and the soil depth becomes insufficient

Discussion & conclusion

- The conditions of PES, are satisfied
  - Agro-pastoralists are SWC service providers
  - Rice growers are buyers of SWC services
  - SWC services are identified and evaluated
  - SWC costs are estimated

- Financing of PES
  - Agro pastoralists realize free SWC techniques in their fields because they increase their production
  - Rice growers can finance SWC costs in the degraded area
  - The basic principle of PES can be met

- PES are possible at the local level within the framework of agriculture

Discussion & conclusion

- On the institutional side conditions are being established
  - Basin agencies
  - National coordination of users
- Competition of aid
  - NGOs and government make promises of funding for CES
- It should be require to compare those result with result of central planer model
- It would require further research that include transaction costs (costs institutional control and implementation of the ESC) to judge the effectiveness of PES
- It should also undertake studies that include negotiation between users, suppliers and buyers of environmental services

United Nations University

"advancing knowledge for human security and development"

United Nations University

UNU-INRA

Institute for Natural Resources in Africa

THANKS FOR YOUR ATTENTION

www.inra.unu.edu