CHINA MISSION REPORT

Conservation agriculture and in particular DMCs *(Direct-sowing mulch-based cropping systems)*: an urgent issue and a major challenge for Franco-Chinese scientific research for sustainable development

8- 17 March 2009

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SUMMARY

Mission schedule

Projet III	Arcus – Project Shanghai - Chongming	Reception by Jiao Tong University
7- 8 March	France – Shanghaï	L. Séguy F.Forest CIRAD
7– 8 March	Bangkok - Shanghaï	+ J. Boyer CIRAD
9- March	Chongming Island	+ M. Soulié, P. Dias Agropolis
10- March	Qingpu site	L. Séguy, J. Boyer, F. Forest
10- March	Conference Sciences café	Entire delegation
11- March	Jiao Tong University - Programming	Entire delegation
Feasability	**DMC Projet – Yunnan**	**Reception by Yaas - Kunming**
12- March	Visit Yaas – CIRAD meeting	L. Séguy, F. Forest , Dr Zengh Li
13- March	Visit Wenschan region	“ “ “
14- March	Visit Mengji region	
15- March	Visit Kunming	Departure for Vientiane - Laos
16- March	Possible collaboration on DMC agroecology SCV Laos-Yunnan	**Reception MAF – Vientiane**
17– 18 March	Vientiane - Bangkok - Paris	**L. Séguy, F. Forest**

Principal people met

Shanghaï

Dr Liu Chunjiang	Agroforestry professor, Jiao Tong University
Dr Qiu Jianping	Soil ecology professor, « « «
Dr Li Yinsheng	Soil ecology professor « « «
Dr Danfeng Huang	Ecophysiology professor « « «
Dr Jean Jacques Pierrat	Director Alliance Française Shanghaï
Mr Wang	Agronomy student at Shandong Qingdao University.
Pr Favreau	Biotechnology professor, Shanghaï University

Yunnan

Dr Dai	Director, YAAS
Dr Tao Dayun	Director of international relations, YAAS
Dr Zengh Li	CIRAD INRA representative in Beijing
Dr Aidong Sheng	Director, AERI
Dr Hong Ye Zhu	Assistant Director, AERI – YAAS
Dr Baokun Lei	Agronomist
Dr Shufang Liu	AERI
Dr Yun Li	Vice Director of Wenshan Institute of Agriculture Science
M. Li Cunlang	Breeder, Wenshan AERI
M. Chen Song	Sericulture professor, Mengzi
Mr Ping Huan	Director Silk Worm and Bee Research, YAAS

MISSION OBJECTIVES

Ecoagriculture, as DMC technology developed with CIRAD for years in Brazil and Madagascar, and recently in Laos and Cambodia is a key technology for addressing main issues related to sustainable developpement in unfavourable rural areas. In south Yunnan, this is the situation with a strong requirement of millions rural people for better life and better natural environment. If Agro-ecological technology could promote poverty alleviation, recover of natural condition, and better tomorrow for numerous population, it is the responsibility of scientific community at taking any relevant initiative aiming at providing academic, political, and ecological significance to this DMC dream

The objective of the CIRAD consultancy implemented under AGROPOLIS, YAAS and Cirad financial support was, in this respect, to provide a first assesment *(*)* in the field of DMC agronomy with the purpose at designing a France - China initiative in agroecology able to be implemented in a first step through a pilot project in Yunnan Province, combined with a applied research component with Jiao Tong University of Shanghai.

In this respect, the french consultants had the opportunity at considering about DMC technology the following issues:

- Main issues of agriculture in Shanghaï Province and Chongming island *(emphasis on soil salinity risk)* and in Yunnan Province *(emphasising on environmental problems and rural poverty alleviation).*

1.What about land –water degradation situation and possibilities for mitigation.
*2.*Agro-ecology in China *(what are the experience in the field)* and in Yunnan *(if any)*
3.Organisation of agronomic research and extension in Yunnan
4.Perspective of scientific research applied to DMC taking in account existing and desirable collaboration between Yaas, Jiao Tong Universities and Cirad.

- Giving first ideas for a Yunnan pilot R&D initiative with proposed project area and project main issues.

(*) It is important to note that experts spent a very brief amount of time in the field during this mission, too brief at least to make an in-depth diagnosis in either the region of Shanghai or Yunnan. Due to the rapidity of this preliminary investigation, we can suggest only very broad directions regarding conservation agriculture and in particular DMCs; the cover crops indispensable for the rapid construction of operational DMC scenarios are indicated for the various environments and landscape units encountered.

Cartography of China: Shanghaï and Yunnan

ABSTRACT

. Tour of Shanghai region and Chongming Island -— Jiao Tong University *(Franco-Chinese ARCUS project).*

. Tour of Southeast Yunnan. Route Kunming — Wenshan – Mengzi – Kunming – YAAS University.

Seen on Chongming Island and areas around Shanghai (Qingpu) :

- **In the field**: Agroforestry work *(Dr. Chunjiang Liu)*, very intensive cropping system. Rice/wheat with tillage, burnt straw, massive use of chemical fertilizers including N *(> 240--300 kg/ha/year)* on slightly alkaline, hydromorphic alluvial soils with a varying water table.

- **Jiao Tong University**: Multi-disciplinary complex with state-of-the-art equipment and top level scientists.

Proposals:

→ Improve agroforestry DMC systems to be "as fully ecological as possible".
→ Convert the existing rice/wheat system into a DMC with management of straw combined with live perennial legume covers planted in the wheat and controlled by irrigation water in the rice → Rapid reduction of chemical inputs to quickly achieve organic rice/wheat production with clean soil and water without productivity loss.
→ DMC rice/wheat systems set up on farms and on the University campus to serve Franco-Chinese PhD trainings on major biology topics at the heart of DMC operations *(carbon sequestration, pertinent global biological indicators, microbial ecology tools, ecology engineering x ecosystem services including phytoremediation, optimization of "genotypes x environments x soil and crop management mode" relationships).*

Seen in southeast Yunnan (Wenshan)

- Mediterranean red soil *(fersiallitic)* on upland peneplains and on low mountains +/-- leached, active degradation under heavy tillage; mountains farmed from top to bottom, manure carried up on people's backs, 1000 m²/worker. On the plains, irrigated rice farming on the lowest lying zones during the hot season, potato on straw beds (*rice straw*). Vertisol +/-- saline bordering on red soil on the **large upland plains** planted with fruit trees *(grape vines, Eriobotrya japonica, Punica granatum, Morus alba, various fruit trees)* as in the Mengzi region.

- On extremely steep slopes → maize intercropped with sweet potato in the hot season *(on these soils, rapid fall of organic matter).*

- On the plain, very intensive system on tilled soil + plastic over vast surface areas, irrigated by small hill reservoirs; maize, pepper, tobacco crops in the hot season *(tropical climate)*, wheat + strong diversification of market garden produce in the cold season.

Proposals

→ *Enormous work* to do with fertility regenerating DMCs, intensive sustainable agriculture with minimal chemical inputs, on both mountain and plain agriculture.

→ Very intensive, very diverse DMCs to be built:

On the plains:

→ DMC on live plant covers *(multiple agrosystemic services)* with buried drip irrigation *(+/- 20 cm)* sustaining very diverse associated crops *("mini-forests").*
→ Under irrigated trellis fruit crops, install plant covers that do not require maintenance and provide extensive ecosystemic services.
→ On rice paddy fields, beyond the rice-potato system, build very productive DMCs with little chemical inputs, including N → towards increasingly biological, ecological DMCs.

In the mountains:

→ Urgent priority: stop tillage; focus instead on protecting soil with cover crops.
→ Build very intensive DMCs on live and dead covers based on maize + sweet potato *(traditional system)*, maize associated with biodiversity combinations that provide at no cost enormous ecosystemic services which economize inputs and protect the environment *(maize + Stylosanthes, maize + Desmodium (uncinatum + intortum) maize + (Finger millet + Cajanus)*, maize + soya, maize + *(oat + vetch)*; soya + *(oat + vetch)* etc… and these same crops on perennial legume covers.

→ As in Chongming-Shanghai, YAAS University has excellent laboratory equipement and young, highly skilled, highly motivated, multi-disciplinary teams. The same major scientific themes cited in the case of Chongming-Shanghai centered on soil biology could be the focus of Franco-Chinese PhD. trainings *(ex: CIRAD + Inra Dijon team + University YAAS).*

THE URGENCY: If CIRAD and Agropolis trully want to become involved in China and succeed in their efforts, the urgent priority is **to train Chinese managers in DMC.** This accelerated training could rely on exchanges:

- Training of Chinese colleagues in Laos + Cambodia, **this implies maintaining and consolidating our DMC system that has been in place for 8 years,** particularly as the next AFD project + other donors must invest enormous resources starting from 2010 *(thus a question of **internal coherence**).*

In return, our CIRAD colleagues in Laos and Cambodia who are DMC experts *(F. Tivet during his mission in Laos, P.Lienhard, F. Jullien, P. Julien, S. Boulakia and S. Chabierski + M TQ Hoa (support mission!)* could assist in **setting up DMCs in Yunnan** at key moments in the calendar. These training exchanges therefore would take place as missions in both directions *(+/-- 30 days/year)*; the PhD trainings could start as soon as the experimental systems, built on a strong diversity of contrasting cropping systems, have been established and are well under control.

I – CHONGMING ISLAND AND THE SHANGHAI REGION (QINGPU)

(*) "Concerned by environmental issues, China is seeking alternative development models" → extract from the "Ecology and sustainable development" booklet, a Franco-Chinese ARCUS 2007-2009 project.

1.1 OVERVIEW

1.1.1. Agroforestry *(Dr. Chunjiang Liu, PhD. Shanghai Jiao Tong University)*

. Flat landscape *(nested fill terraces)*, soil either shaded in the case of plantations of evergreen species *(for example, Cinamomum cafora : (photo 1)* or bare and exposed *(manually maintained clear)* during winter in the case of plantations of deciduous species *(genus Metasequoia, Magnolia, etc…)*; shrub plantations are planted on well drained beds that require extensive labor to maintain clear *(photo 2)*. These plantations benefit from an irrigation-drainage system *(cement canals)*; however, groundwater continuously remains very close to the surface even at the end of the dry winter season *(60-80 cm from the surface)*; presence of white saline efflorescence about 40 cm deep on vertisols *(pH alkaline).*

. Attempt to introduce covered shrub species of evergreen *Cinamomum canfora* (*Buxus sempervirens*) *(photo 3).*

Photo 1 – Evergreen species *(Cinamomum) (Chonming)*

Photo 2 – Deciduous species on beds *(Chnonming) (Azolla in the canal)*

Photo 3 – Cinamomum + Shrub *Buxus s. (Chonming)*

1.1.2. Intensive cropping systems with tillage on alluvial terraces *(Chongming Island, Qingpu region)*

Key words and expressions: Intensive cropping systems; annual wheat-rice successions; hydromorphic and vertisol alluvial soils +/- saline; year round varying water table; very strong mineral fertilizer, including N *(>240-300 kg/ha/year)*; pesticides *(herbicides, insecticides)*; anaerobiosis on wheat; weed and Mediterranean type ornamental flora.

. Intensive system built on widespread successions: rainy hot season rice / drier cold season wheat. On the best drained natural levees and upland zones → plantations of food or oil-producing cruciferae (*Raphanus campestris and raphanistrum*).

. Growing wheat *(soft wheat)* suffers from *anaerobiosis* despite the small drains made with trench ploughs every 3-4 m, the wheat cultivated on well-drained, elevated levees is 2 to 3 times more developed *(cf. photos 4 and 5).*

. The weed flora are Mediterranean types: genus Cirsium, Daucus, Sonchus, Galium, Geranium, Euphorbia, Veronica, Rumex, etc…*(cf. photos 6, 7, 8, 9).*
. The productivity of wheat would be 4 to 5 tons followed by 6 to 8 tons of rice *(very "tight" farm calendar)*; high use of nitrogen fertilizer on this intensive cereal succession: between 240 and 300 kg N/ha/year; pesticides are used such as Fenoxaprop on wheat etc…

(*) This intensive rice/wheat system is widespread in the region → any technical, economic, or ecologic improvement will have ***an enormous impact****; it thus represents an enormous regional challenge! But any improvement also would be of interest to other exclusively cereal-based systems in the world: India (rice/wheat), Mexico (maize/wheat)…*

Photo 4 – Wheat on well oxidized soil in front *(Qingpu)* and hard wheat on rice fields *(anaerobic)*

Photo 5 – Small drains to oxidize the profile under wheat on rice fields *(Qingpu)*

Photo 6 – Temperate, *Mediterranean flora : Gallium a.*

Photo 7 – Temperate, *Mediterranean flora : Gallium a. + Veronica sp.*

Photo 8 - Temperate, *Mediterranean flora : Gallium a. + Euphorbia h.*

Photo 9 – *Euphorbia h. + Veronica sp.*

1.2. WHY DEVELOP SUSTAINABLE AGRICULTURE SCENARIOS – PARTICULARLY DMCs – IN SUCH AN ECOLOGY, HOW MAY ONE PROCEED, AND WHAT ARE THE EXPECTED BENEFITS?

- Why?

"The Government of China and the Municipality of Shanghai created a pilot ecological project site on the scale of an island, integrating ecological agriculture, clean and innovative industries, "green" real estate, ecotourism… in other words, a true model of ecological and sustainable development. A symbol for the 2010 Universal Expo, it reconciles economic growth with respect for the environment" *(extract from the Franco-Chinese ARCUS 2007/2009 project, in the annex).*

This project has an exceptional scientific environment: 4 Shanghai universities, equipped with state-of-the-art laboratories and top level research scientists + 9 French research partners *(cf. ARCUS booklet)* working together on 15 innovative research programs organised around 3 themes: sustainable management of water, energy and waste; ecology; and eco-agriculture.

Given the high level of urbanization on the island and around Shanghai, the widespread practice of intensive agriculture using large amounts of chemical inputs (*chemical fertilizers including strong doses of N, pesticides*) with a varying water table, these 3 research themes are extremely important.

The experience we have earned over the last 25 years in the domain of the ecologic management of crops and soil at an agro-ecological network scale enable us to suggest the following DMC technical proposals. In both the field of agroforestry *(remarkable work of Dr. Chunjiang Liu)* and that of

intensive agriculture, these DMC proposals should assist the positive development of existing systems within the framework of the objectives set, and contribute diverse additional ecosystemic services free of cost:

- Complete and permanent soil cover,
- Strong carbon sequestration and associated increase in organic N and the biological life of soil,
- Buffer effect on salinity,
- Natural control of weeds and crop pests.

These ecosystem-based services should make it possible to:

- Increase the productivity of agroforestry and intensive cropping systems *(rice/wheat)*,
- Improve their technical feasibility,
- Drastically reduce production costs and environmental pollution,
- Rapidly construct DMC systems meeting organic agriculture norms.

Or progressively substitute an energy - crops model based on industry with a new one based on agrobiology.

- How?

The first step in the construction of these DMCs is to *introduce the plant species* which will constitute the crops which will permanently cover the soil. These cover crops will replace intensive mechanical tillage by biological tillage.

1) In agroforestry systems

4 possible options:

1) Herbaceous plant covers that require no or minimal maintenance.
2) Herbaceous plant covers able to support crops in the hot season and/or cold season.
3) Decorative and fragrant plant covers that could constitute undergrowth beneath evergreen shrub species *(ex: Cinamomum canfora).*
4) Winter crops whose residues will serve as dead cover during the hot and rainy season.

. Herbaceous plant covers that require no or minimal maintenance under deciduous trees and which can support cold season crops (*options 1 and 2).*
→ Among graminaceae:

- ***Pennisetum clandestinum*:** cultivars whittet and Noonan *(Australia – Heritage seeds)*; green in the hot season, excellent fodder, strong restructuring of soil, controlled by the cold.
- ***Paspalum notatum***: cultivars Pensacola and Batatais; same properties as *P. clandestinum*; the cultivar Pensacola is resistant to some frost *(Brazil).*
- ***Axonopus compressus*** *(Weed of "Sao Carlos")*: this species tolerates shade and is the only one that can survive in shade *(Brazil).*
- ***Zosia tenuifolia, japonica***: Blanket requiring no maintenance *(Korea).*

- ***Cynodon dactylon***: *(Mix of fertile seed ecotypes) (Brazil).*

*(*) All of these plant covers can be produced in **rolls** or **sheets** that can be installed very rapidly (like on soccer fields).*

*All of these species wither in the cold and **may be planted** with **cereal** during the cold season: soft wheat, hard wheat, barley, associated or not with vetch → Vicia sativa and especially **Vicia villosa,** without any use of herbicide, and also with **cruciferae**: Raphanus campestris and raphanistrum, Sinapis arvensis (mustard) canola, etc…*

→ **Among creeping legumes:**

- *Trifolium repens (very abundant by the side of the roads on the island),*
- *Médicago lupulina, (France)*
- *Lotus uliginosus, cultivar maku (Australia),*
- *Lotus corniculatus (well tolerates hydromorphy) (Brazil),*
- *Trifolium semipilosum (Kenya)*

*(*) None of these legumes require maintenance; they form a **permanent blanket** under deciduous trees, enriching the soil with N which promotes tree growth and naturally controls weeds. They may be sown or planted, like the vetch grasses mentioned previously, by laying out rolls or sheets of the plants. **Once planted**, these legumes can receive winter crops: soft wheat, hard wheat, oats, barley…cruciferae (genres raphanus and sinapis), with a minimum of chemical inputs, particularly N.*

→ **Among erected crops legumes, more developed in height,** which require periodic maintenance with a cutting roller:

- Alfalfa *(Médicago sativa)* – Australian Alfalfa « super 7 » *(France),*
- *Hedysarum coronarium (Tunisia),*
- *Ornithopus sativus (Brazil),*
- *Lathyrus sativus*
- *Onobrychis viciifolia (France)*
- *Melilotus albus* and *officinalis (the latter has medicinal properties) (France).*

→ Buckwheat *(Fagopyrum esculentum),* which has the same chemical mineral composition that wheat *(without gluten)* and naturally controls weeds, is a honey plant *(France).*

(*) All of these legumes, like the creeping legumes, fix high quantities of N/ha, are adapted to alkaline soil and are honey plants → an association with apiculture thus is possible. Like creeping legumes, erect legumes can tolerate the same winter crops (wheat, oats, cruciferae). All of these erect legumes, like the creeping legumes, must be planted at the end of the hot season (autumn) in humid soil.

→ **Winter crops whose residues will serve as dead cover during the hot rainy season**

• Winter crops are possible under deciduous trees. As the shrub plantations are installed on well drained beds, winter crops such as hard and soft wheat, oats, and barley associated or not with vetch *(Vicia sativa, villosa)* may be very interesting economically and use the same amount of labor that now is consecrated to maintaining the soil bare and unproductive in winter. After the harvest, the

cereal straw will be respread on the ground to protect the soil in the humid season, control weeds, and increase fertility *(increasing stock of organic matter + creation of powerful biological activity: creation of free, organo-biological based fertility).*

. Plant covers under shrubby evergreen stands *(ex: Cinamomum canfora)*

. To build stands with permanent soil cover providing numerous ecosystemic services free of charge, the herbaceous cover always must be installed first. Once the soil surface is completely covered by the herbaceous cover, shrub plantations may be planted. It also is necessary to choose perennial herbaceous species that tolerate shade well:

- *Axonopus compressus*, if winter frosts are infrequent, or *Paspalum notatum* cultivar Pensacola which tolerates frost well, among the Poaceae *(grasses).*
- prostrate legumes cited earlier, such as *Trifolium repens*, semi-pilosum, *Lotus corniculatus* and *uliginosus*, *Medicago lupulina*, and combinations of these diverse species that also may be suitable.

. It also is possible, according to the objective fixed, to plant high value, medicinal species that tolerate shade well beneath these evergreen shrub covers *(to explore and test based on the vast Chinese pharmacopoeia).*
. If the objective is decoration or fragrance alone, different shrubs may be installed beneath the shrub cover; among the most interesting are:

- *Aucuba japonica, Buxus sempervirens (already made by Dr. Liu), Choisya ternata, Daphne mezereum, Euonymus japonicus, Hedera helix, Hypericum calycinum (medicinal), Ilex aquifolium, Mahonia aquifolium, Osmanthus aquifolium, Phillyrea decora, Prunus laurocerasus, Ruscus racemosus, Viburnum rhytidophyllum, Taxus baccata, Thuya plicata.*

*(*) All of these ornamental shrub species may be installed under the shade of Cinamomum. The shrub species genus **Populus** and **Platanus** also should be tested as a main cover.*

2) Transform rice/wheat cereal systems with intensive tillage into DMCs

. As currently practiced, it is impossible to "find a place" for intercrops that could replace tilling *(ploughing machine, rotary hoe)* in the very intensive cereal systems.

. The construction of high yielding DMC systems on the same succession during hot and rainy season rice/quasi-dry and cold season wheat must incorporate numerous free ecosystemic services, of which the most important are:

- Fixing a maximum of nitrogen,
- Reducing chemical inputs, and therefore costs and pollution *(varying water table)* by agro-toxics and N.
- To improve their technical feasibility, liberating labor to make organic composts from cereal straw that currently is burned – the most often for announced yields of 4-5 t/ha of

wheat followed by 6-8 t/ha of riz/year, the burning of straw consumes between 6 and 8 t/ha of carbon that goes up in smoke!

. Given the very tight annual rice/wheat calendar, the construction of suitable high-yield DMCs takes place through an *association of legumes with wheat;* if the legumes are competitive, they may be drowned by the depth of the irrigation water. These legume covers must be maintained permanently in place, they therefore must be kept alive by appropriate management *(non-polluting).*

Diverse scenarios may be built which incorporate legumes such as *Trifolium repens, incarnatum, semipilosum, Lotus corniculatus (well adapted to hydromorphic soils)* and *uliginosus (cv. Maku),* and/or a mix of diverse species *(better stability – perennity faced with climate variability)*; all will lead rapidly to production of clean soil and **water** through increasingly ecological managment *(organic production).*

For example, once the best performing "live cover" legumes are selected, DMC scenarios could be set up using broadcast sowing of wheat, rice, and cover legumes alone combined with straw restitution:

→ At the swelling stage of broadcast rice:

- *Trifolium alexandrinum* or *Trifolium incarnatum*, *Lotus corniculatus*, mixed,
- Then barley or wheat before the rice harvest.

→ Immediately after the rice harvest, the straw is brought back and spread on the rice paddy fields + 3-5 t/ha of manure; the legumes and the cereal grow together *(some of the rice straw may serve to make compost).*

→ At the ear emergence stage of the cereal *(wheat, barley),* rice seeds are broadcast,

→ When the cereal is harvested *(barley, wheat)* the straw is brought back and spread uniformally on the rice fields + 1.5 to 3 t/ha of manure or compost.

*(*) **Competition** between the associated legumes that are maintained alive is controlled when necessary in the rice by the depth of the irrigation water.*

Various other DMC scenarios** may be built -- without any tillage – that use mechanized direct sowing of cereals rather than broadcasting seeds**. All of the proposed scenarios require extensive agronomic and technical understanding of DMCs.

***. To gain added value in the DMC scenarios**, **hard wheat** should be tested because it earns 50 to 70 % more than soft wheat on the world market. In the same spirit, barley, which is better adapted than wheat to alkaline soil, could be tested (beer brewing, cattle feed).*

. Setting up these "clean" DMCs is a major challenge for CIRAD, given the immense surface areas covered by rice/wheat systems in both China and elsewhere in the world (India: rice/wheat; Mexico: maize/wheat etc…).

II – YUNNAN PROVINCE

(*) Cirad and Yaas have been developping scientific relationship for more than 5 years in the field of agroecology. Short term consultancies have already been implemented in Agroecology (A. Chabanne in 2005) and several meetings at Kunming or Vientiane undertaken under the Mekong GMS umbrella gave opportunities for scientists and agronomists at sharing informations and perspectives. More recently, in the follow up of the regional Mekong conference of Phonsavannh in Laos (October 2008), YAAS and Cirad decided to boost partnership for developing agroecology in Yunnan through the called SIFROSA[1] initiative, that was finally signed between Cirad and Yaasat Montpellier, September 2008.

With the ARCUS initiative devoted to the development of scientific partnership between China and France, in our case with Jiao Tong Universiy in Shanghaï , it was of due interest at analyzing the possibility of building a Cirad YAAS – Jiao Tong platform with the aim at creating a strong and large initiative in agroecology for China, focusing both on an ambitious R&D project in Yunnan and both a sound research component with Chinese universities.

The visit to Yunnan was so devoted at identifying the main issues and challenges with the objective at implementing a first feasibility appraisal to the attention of French and Chinese authorities.

[1] Sino French Initiative on Sustainable Agriculture

2.1. RAPID OVERVIEW

. **Itinerary:** Kunming - Wenshan – Mengzi – Kunming, or, in other words, the southeast region near the border to Vietnam *(cf. attached map).*

. **Landscape units and soils:** Landscape dominated by a tropical climate and a calcareous geomorphology: karst topography *(sugar loaves)* and low mountains *(altitude 1000 – 1600 m)* in strong strike and dip limestone layers resembling those found in the region of southern France near Toulon, are intersected with numerous low valleys *(peneplains)* that may spread out widely as in the Mengzi region.

Throughout this trip through calcareous landscapes under a tropical climate *(cf. climatological data in annex)*, **the soil was ruby red, Mediterannean red** *(more or less leached fersiallitic soils)*; where the soil is thin (*pockets of dissolved limestone)* and dominated by boulders, the land is covered by pine forests, *(cf. photos 10).* Once **soil depths increase, the land is put under cultivation using intensive labor on all of the landscape units, from the top of the mountains down to the floor of the valleys**: over time, even the steepest slopes *(> 30-40 %)* have been shaped into successive, inclining planes on which the angle of the slope is more gentle but remains very steep *(cf. photos 11 and 12).*

. Despite rainfall of approximately 1000 mm, enormous erosion damage may be seen *(deep gullies, "lavakas")* except on certain slopes > 40 % that are thinly covered with soil *(→ landslide cuts –(cf. photos 13, 14 and 15).*

. Wide variations in color, ranging from brownish red to light yellow, nevertheless indicate that the **losses in organic material are high**, often facilitated by the thinness of the soil *(cf. photos 16 to 20).*

. Overall, the humus of these soils *(calcic mull)*, provide strong structural stability that has helped avoid the gigantic, catastrophic erosion on acid rock *(sandstone)* in humid tropical zones *(ferrallitic soils) (photos 21 to 26).*

. Under intensive tillage *(continuous labour)*, soil fertility is, however, constantly being reduced and farmers carry manure up the steep slopes on their backs *(exposed, continuously leached fersiallitic soils) (photo 27).*

(*) In such very steep landscape units, DMCs will enable:

- *To completely protect surface soils, and therefore to stop erosion and strong leaching of mineral nutrients.*
- *To regenerate soils under crops (strong C sequestration, strong retention of nutrients in the clay-humus complex).*
- *To diversify production.*
- *To produce more with a minimum of inputs and with less back breaking labor.*

Photo 10 – Karst landscape + pine trees *(near Kunming)*

Photos 11, 12 – On enclined planes on hills + intensive crops on plastic on the plain *(Wenshan-Mengzi)*

Photo 13 – Catastrophic erosion on tilled soil

Photo 14 - Catastrophic erosion on tilled soil

Photo 15

Photos 15 to 18 – Montains cultivated from top to bottom, active degradation of soil underway (Mengzi)

Photos 16 -17

Photo 18

Photos 19 to 20 – Wide variations in color linked to soil tillage (road from Wenshan to Mengzi)

Photo 19

Photo 20

Photos 21 to 26 – Karst landscape, tilled soil on mountain slopes and terraces on colluvial Soil at the bottom of a slope *(Wenshan-Mengzi)*

Photos 21-22

Photos 23-24

Photo 25

Photo 26

Photo 27 – Manure hauled up on people's backs in the mountains *(Wenshan-Mengzi)*

Alongside the DMCs, cash shrub crops could be planted at the base of the inclined planes that descend from the tops of the mountains down to the valleys. This would provide even greater stabilization to these landscape units and provide diversified supplementary income to farmers who are very poor and have only 1000 m² of arable land available per worker!

Intensive agriculture thus is mandatory, but it also must be sustainable: DMC + cash shrub plantations definitely would be a more efficient option than the current agriculture situation; it should help reverse the continuous degradation of the existing soil heritage so that the soil may rapidly regenerate under cultivation.

. In the valleys *(peneplains)*, red soil alternates with vertisols; the latter assume increasing importance as the aridity of the climate becomes more pronounced *(presence of Agaves sisals)* and are the seat of saline influence below depths of 40-60 cm at the end of the cold and driest season *(Mengzi region; photo 28)*; in the lowest parts of the landscape, **irrigated rice agriculture** is practised, often followed in the cold season by potatoes cultivated on well drained beds covered with rice straw.

. On the upland zones of the plains, very intensive cropping systems with continuous tillage is the rule:

- Maize, pepper, tobacco, are cultivated on well drained beds *(red clay soil)* in the hot and rainy season between May and September/October; in the cooler and drier season: wheat crops and diverse market produce *(cruciferae, peas, beans, etc…)*.

All of these crops **could be irrigated** using hill reservoirs *(government development plans)*. Intensive fruit crops often dominate on these elevated valley soils:

- Grapevines,
- Fruit trees such as loquat *(Eriobotrya japonica)* and pomegranate *(Punica granatum)* occupy thousands of hectares in the Mengzi region.
- Mulberry *(Morus alba)*, for silkworm farming *(Mengzi)*, on which a magnificent and imposing specialized YAAS research center is working.

These shrub crops benefit from drip irrigation *(presence of saline efflorescence at shallow depths) (photos 29 to 33)*.

*(*) The most intensive irrigated cropping systems most often are under **plastic covers**; these covers are replaced every year and constitute a very worrying source of environmental pollution. (It takes over 300 years for plastic to decompose → it rapidly becomes cumbersone and will obstruct water flow structures in the lower parts of the model).*

The DMC systems offer the same advantages** as plastic covers in terms of water efficiency and soil temperature regulation, **but, in addition, enables an increase in cultivated soil fertility** and thus **sustainable production with decreasing amounts of chemical inputs.

Photo 28 – Saline efflorescence on vertisol and *Bermuda grass (Mengzi)*

Photo 29 – Irrigated vineyard *(Mengzi)*

Photo 30 – Mulberry *(Morus alba*) for silkworm production *(Mengzi)*

Photo 31 – Mulberry with cover of *Paspalum not. pensacola (Mengzi)*

Photo 32 – 33 – Mulberry with alfalfa cover crop *(Medicago sativa)*

Photo 33

2.2. HOW TO BUILD THE DMCs, WORKING FROM THE AGRICULTURE DIVERSITY ENCOUNTERED?

(*) Like in the case of Chongming Island, the first step is to either introduce or locate in the Chinese germplasm cover crop species and evaluate their performance (cf. chapitre 3).

. First point: Given the limited amount of cultivated surface area available per worker *(+/- 1000 m²)*, the construction of the DMCs must be based on cropping systems that are very intensive (*quantitative criteria)*, very diversified *(quality and food security criteria)*, and with high production rotation capacity *(necessity and food and commerical demand criteria)*, **from the moment irrigation is used on plains.**

2.2.1. DMC on plains *(starting from existing crops)*

→ **Cover plants** – despite the tropical climate, the cool season between November and March makes it possible to **try testing the same species proposed for Chongming** in a Mediterraneann type of climate. *(cf. list of species in chapter 1.2).*

In addition to these species, the performance of other tropical species also must be tested: among **legumes:**

- *Arachis pintoï (ornamental in Mengzi)* and ***Arachis repens*** *(see CIRAD in Brazil: ecotype/Séguy, Bouzinac, Taffarel family, exclusivelly vegetative propagation),*
- *Centrosema pascuorum (Laos),*
- *Cassia rotundifolia (Laos),*
- *Stylosanthes guianensis (CIAT 184) (Laos – Cambodia),*
- *Desmodium intortum (silver green), Desmo. Uncinatum (silver leaf) (Laos, Madagscar),*
- *Crotalaria spectabilis, retusa, juncea (Laos – Brazil),*
- *Cajanus cajan (2 ecotypes of Brazil – Laos),*
- *Vignas umbellata and unguiculata (Laos).*

Among graminaceae:

- **Idem Chongming list,**
  +
- *Eleusine coracana,*
- High protein sorghum without tanins,
- *Brachiaria ruziziensis, decumbens and brizantha,*
- *Panicum maximum (diverse ecotypes).*

(*) Most of these "cover plant" species can be obtained from our colleagues at UR1 SVC – CIRAD in Laos and Cambodia.

→ **DMCs to be built beneath orchards, grapevines, mulberry**

(*) given only as an example, these must be precisely defined after the first year of evaluating the "cover plant" species.

1st rule, *(reminder)*, which must be followed to set up the **DMC orchards**:

- **The cover crop must be established first,**
- Then, once the soil is completely covered by this crop → plant orchard.

The "cover crop" species must be tested and evaluated both on beds where the trees are planted, and on the drains that separate the beds *(salt adaptation test, on vertisol)* → **the entire surface area therefore must be sown.**

Experiment first with creeping, prostrate, and legume "cover plant" species, preferably**:**

- *Arachis pintoï* and *repens*
- *Centrosema pascuorum (Laos),*
- *Cassia rotundifolia*
- Desmodium untortum (green leaf)
- Desmodium uncinatum (silver leaf)

} planted at the first rainfall of the hot season

- *Trifolium repens, semi-pilosum*
- *Lotus corniculatus, uliginosus,*
- *Medicago lupulina*

} planted at the end of the rainy season

(*) To evaluate them → cf. Chapter 3.

→ DMCs to be built on food crops on plains

The main objective, given the requirement of maximum intensification, is to try to build DMCs on permanent, live covers as soon as irrigation is available.

To increase **water efficiency**, the best performing DMC systems are planted on permanent cover crops *(multi ecosystem-based services)* and irrigated through an underground network *(at a depth of 20 to 30 cm)* of drip pipes that resist degradation *(20 to 30 years → Israeli material).*

This combination of drip irrigation with DMCs on permanent cover crops makes it possible to irrigate a greater surface area than the existing system.

. On this permanent cover, DMC systems may be built from **crop associations** with a high level of **biodiversity** that meet economic and food needs → fields cultivated with several associated species become "**mini-forests"** of **biodiversity** that can resist attack from pests and myscosis due to its stand structure.

Ripe species are harvested and immediately replaced by new crops in the complex associations.

*(*) The plastic covers that cover huge surface areas should be **rapidly replaced by biodegradable plastic covers** (made from maize, manioc)…while waiting for the DMCs that offer the same benefits (water saving, weed control, temperature regulation) in addition to ecosystem-based services that increase fertility under cultivation.*

→ DMCs to be built on steep slopes of low mountains *(red fersiallitic soil)*

. The existing system, which is practiced over enormous surface areas with intensive tillage, associates maize with sweet potato.

. The DMC systems to be built *(there are many options)*:

- Maize associated with food cover crops such as *Vignas umbellata, unguiculata, Eleusine c., Cajanus cajan,* important soil cover biomass for the following year, in rotation with maize + sweet potato.
- Maize on permanent cover crops of *Arachis pintoï, Arachis repens, Cassia rotundifolia.*
- Maize on covers of *Stylosanthes guianensis (Stylo. 184)* in rotation with maize + sweet potato,
- Maize + *Brachiaria ruziziensis* + *Cajanus cajan*, with the same rotation: maize + sweet potato, etc…
- Maize + creeping legumes at the end of the rainy season *(genres Trifolium, lotus, desmodium),*
- Maize + *(oat + vetch)* at the end of the rainy season.
  Etc…

and numerous other possible DMCs built based on coix (*Coix lacrima Jobi*) and soya: soya + *(oat + vetch)*, soya + beans, soya + *(Brach. + crotalaria)* and practiced **in rotation with the preceding systems based on maize**.

(*) One may likewise give several DMC examples that would be possible on rice paddy fields (rice + market vegetable produce), that enable the natural control of blast disease …to be explored later.

III - HOW MAY AN EFFECTIVE PARTNERSHIP IN THE DOMAIN OF CONSERVATION AGRICULTURE (DMC) BE ESTABLISHED BETWEEN CIRAD AND TOP CHINESE UNIVERSITIES *(JIAO TONG, YAAS)?*

3.1. SEVERAL SUGGESTIONS THAT MAY BE RAPIDLY IMPLEMENTED

. The first step of this partnership should be devoted to the introduction and evaluation of a large "cover crop" species germoplasm to add to the species already used and available in China *(Trifolium repens, Arachis pintoï, etc…).*

. The evaluation of these "cover crop" species, in both Chongming and the diverse regions of Yunnan, will examine:

- Their growth rate and soil cover,
- Their capacity to compete with local weeds in both the dry and rainy seasons,
- Their annual biomass production, and their mineral composition *(C, N, P, K, Ca, mg, Na, and trace elements zn, mn, Cu, mo, B),*
- Their performance in relation to myscosis and pests,
- Their reproduction capacity.

. They will be established using collections *(20 to 40 m²/species)* covering the entire model in place *(ridges, beds, and drains)*; tropical species *(cf. list chapter 2)* must be planted at the beginning of the rainy season, temperate subtropical species between 30 and 45 days before the end of the rainy season and the arrival of the cool season.

(*) This plant material constitutes the building "blocks" of direct-sowing mulch-based cropping systems (DMC).

. In order to master these cover crop species and then build DMCs, our partnership could be base on:

- training exchanges → Our Chinese colleagues could be initiated in DMC in Laos and Cambodia where CIRAD and its partners have installations that have been operating for 7-8 years in different ecologies, including very diversified DMC scenarios.

- conversely, our highly skilled colleagues at CIRAD *(Laos and Cambodia teams)* could help our Chinese partners establish this germoplasm under the best possible conditions in China.

These training exchanges would take place in the form of missions.

- Once DMC systems have been set up *in situ* in China and on large university campuses *(Jiao Tong, YAAS)*, **trainings for French and Chinese PhD students** will be undertaken on the main scientific themes, namely:

- Carbon sequestration,
- Pertinent global biological indicators,
- Soil biological life dynamics in function of the nature of the DMC *(biodiversity, biomass quantity and quality).*
- Microbial ecology tools → Impact on the agronomic and economic performances of DMCs.
  . Trichoderma, endomycorrhizas, etc…, conditions of conserving and multiplying strains according to the nature of the DMCs.
- Ecological engineering: DMCs with increasing biodiversity and ecosystemic services that include phytoremediation and completely "organic" DMC.
- Optimisation of "genotype x environment x soil and crop management modes" that aim, beyond system productivity, for the natural reduction of attacks by myscosis and crop pests *(selection for and in cropping systems).*

(*) Chinese universities that were visited rapidly are equipped with state-of-the-art laboratories; these are top level universities capable of housing doctoral training programs in partnership with French teams (cf. ARCUS project example) in the field of agroecology.

- Lastly, once operational, this partnership will be the topic of **periodic scientific seminars** *(knowledge, know-how, and make known)***.**

IV – CONCLUSION

This brief *(too brief)* mission allowed us to discover, in both the region around Shanghai and in southeast Yunnan, extraordinary landscapes, extremely welcoming Chinese people, and a fascinating culture.

The intensive agriculture systems, rice paddy water mangement, and farmers who have turned agriculture into a landscape modeling art, are now capable of integrating into their practices conservation agriculture to sustainably increase production.

The issue at stake is crucial to both French and Chinese agronomy research. The prospect of developing DMC techniques on millions of hectares is entirely possible given the quality and motivation of the partners encountered in the field and in the universities. The Chinese universities, which are perfectly equipped in terms of state-of-the-art laboratories and skills, would be top rate scientific partners with whom it will be possible to make advances in earth and living soil sciences within an ancient, rapidly changing culture.

We extend our warmest thanks to all of the institutions and representatives who welcomed us so graciously and professionally.

Citrus orchard with permanent conver crop of Arachis pintoï allowing high quality production without additional labour *(Cirad, Reunion Island)*

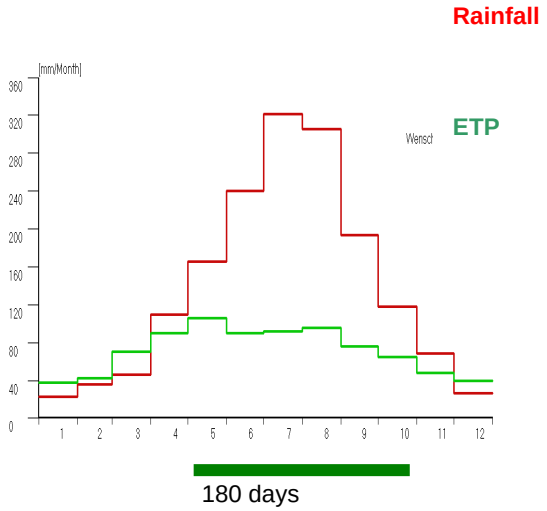
ANNEX

Potatoes on straw's mulch in south west Yunnan

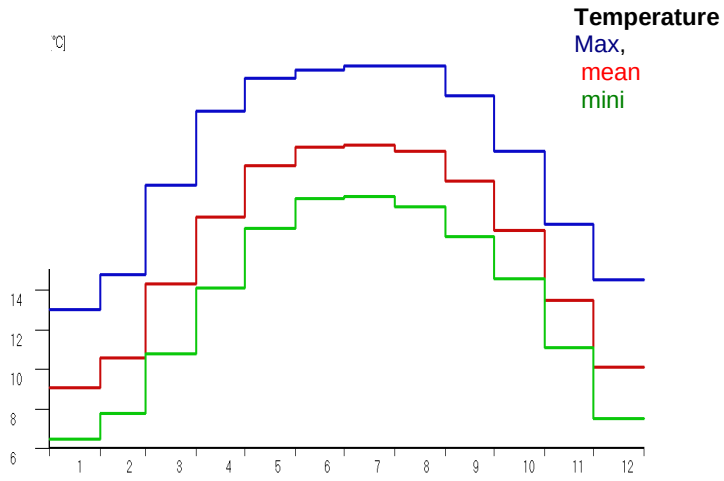
ANNEX I

- Zone de Wenshan - Altitude 1000 m - Pilot Farm Plastic mulch Corn - Soybean

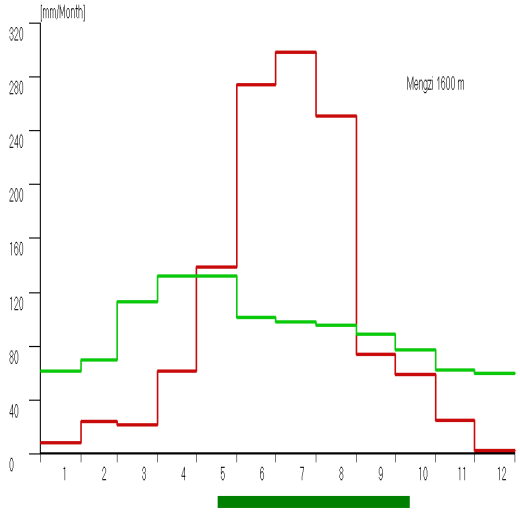
Monthly rainfall and potential Evapotranspiration

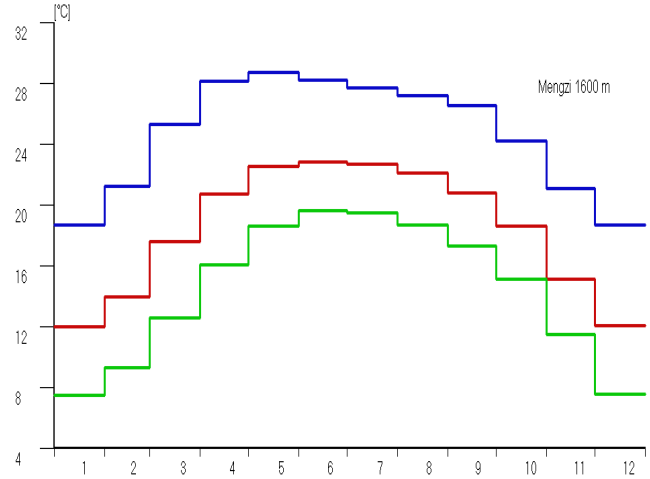


Mean monthly temperature



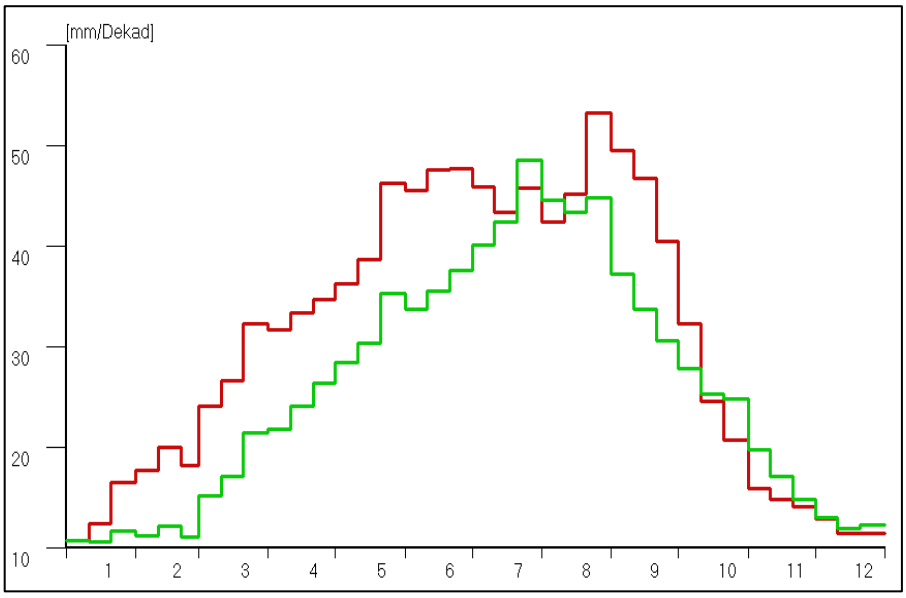
Zone de Mengzi - Altitude : 1300 m Fruit tree, Vineyard, Silk Mulberry

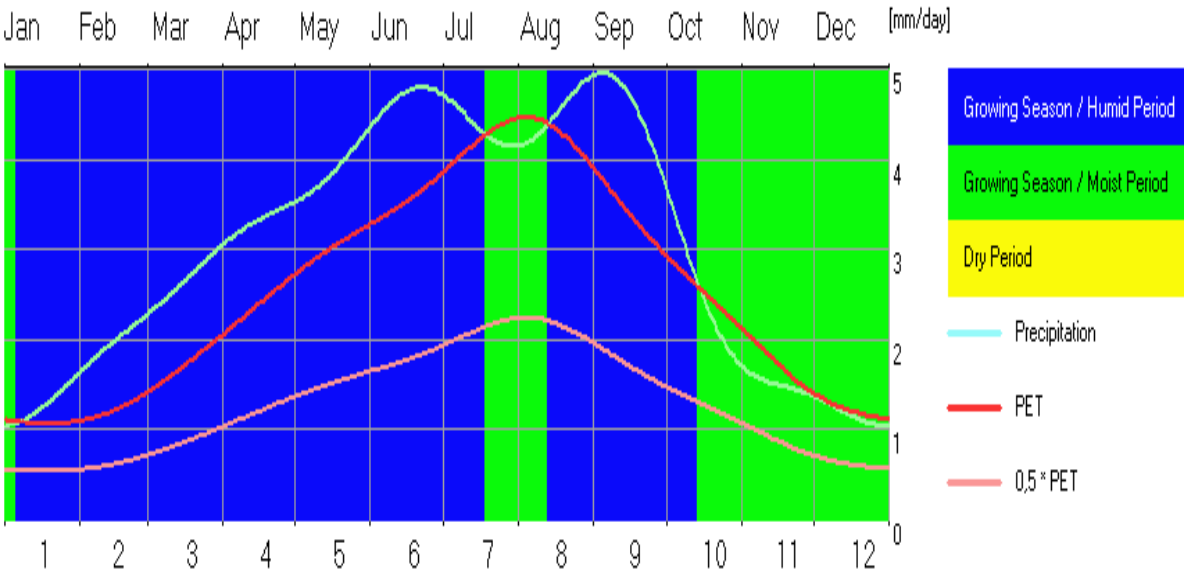




Shanghaï Region

Island of Chongminh





ANNEX II

List of potentially suitable cover crops and origin for Shanghaï region (Chongming, Qingpu) and South East Yunnan (Wenshan and Mengzi)

LEGUMES

- *Arachis pintoi* cv Amarillo *(Brésil – L. Séguy)*
- *Arachis repens (cultivar L.Séguy – Brésil ou Madagascar, R. Michellon)*
- *Cajanus Cajan* – 2cultivars Brésil *(Laos)*
- *Cassia rotundifolia (Laos ou Madagascar, R. Michellon)*
- *Centrosema pascuorum (Laos – Florent Tivet)*
- Collection Haricots (phaseolus) – *(Laos – Madagascar R. Michellon)*
- Collection sojas tropical et subtropical *(Madagascar, R. Michellon)*
- Collection *Vignas unguiculata (Laos – Cambodge)*
- *Crotalaria spectabilis*, *juncea et retusa (Laos, Brésil, L.Séguy)*
- *Desmodium intortum* (green leaf) – Desmod. uncinatum (silver leaf) *(Laos ou Madagascar, R. Michellon)*
- *Hedysarum coronarium (Tunisie, Moncef)*
- *Lathyrus sativus (Brésil - L.Séguy)*
- *Lotus corniculatus (France ou Brésil – L. Séguy)*
- *Lotus uliginosus* cv. Maku *(idem)*
- *Medicago lupulina (France)*
- *Medicago s*. super 7 *(Australie ou Hubert Charpentier, France)*
- *Melilotus alba* et *lutea (France)*
- Ornithopus sativus *(L.Séguy)*
- *Onobrychis viciifolia (France)*
- *Stylosanthes guianensis (Ciat 184)- (Laos)*
- *Trifolium alexandrinum (France – Tunisie)*
- *Trifolium incarnatum (France)*
- *Trifolium repens (déjà présent sur place)*
- *Trifolium semi-pilosum (Australie –heritage seeds ou autre)*
- *Trifolium subterraneum (France)*
- *Vigna Umbellata (Laos)*

GRAMINEOUS

- Avoines subtropicales *(R. Michellon, Madagascar)*
- *Axonopus compressus (Brésil, L. Séguy)*
- Blé dur *(Triticum durum*) – cultivars Tunisie *(Moncef)*
- *Brachiaria decumbens , ruziziensis , brizantha , humidicola* (Laos , Cambodge)
- Collection *Eleusine coracana (Brésil- L.Séguy)*
- Collection Millet (Mils*) (Brésil- L.Séguy)*
- Collection orge *(barley) (Madagascar, R. Michellon + France Inra)*
- Collection Sorghum without tanins *(Brésil L.Séguy)*
- *Cynodon d*. Fertiles *(mixed écotypes – Brésil L.Séguy)*
- *Panicum maximum (Laos, Cambodge)*
- *Paspalum notatum cv. Pensacola (already in fields)* et *cv. Batatais (Brésil L.Séguy)*
- *Pennisetum clandestinum (kikuyu)* cultivars whittet, Noonan *(Australie)*
- *Zosia tenuifolia et japonicum (Corée)*

Polygonaceae
- Sarrazin (*Fagopyrum esculentum*) – *(France, Hubert Charpentier)*

Shrubby species
- Genre Populus *(divers cultivars) – (Europe)*
- Diverses espèces arbustives pour sous bois- cf. liste dans le texte *(Chonming)*
- *(Europe)*

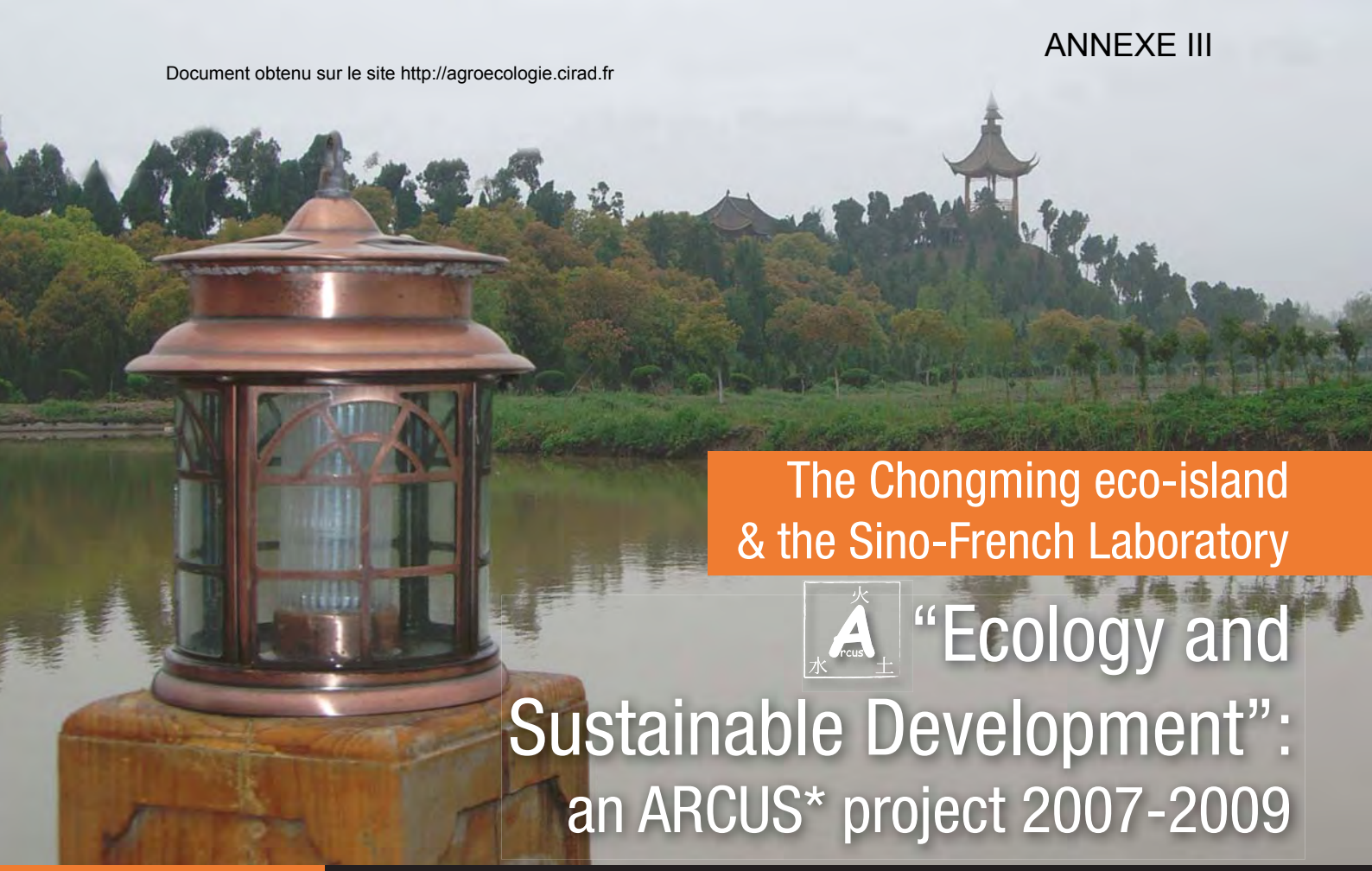
List of CIRAD contacts for cover crops collection & information

Madagascar: roger.michellon@cirad.fr **or** michellon@moov.mg
Brésil : lucien.seguy@cirad.fr and serge.bouzinac@hotmail.com
Laos: florent.tivet@cirad.fr and pascal.lienhard@cirad.fr
Cambodge: stephane.boulakia@cirad.fr or stephane.boulakia@camnet.com.kh
France: christine.casino@cirad.fr and charpentier.hub@wanadoo.fr

ForTunisia and other semi arid related needs:
see France' list

Just a look to Brazil
Mulch from soybean crop under DMC System – Parana – Brazil – 1987

ANNEXE III



The Chongming eco-island & the Sino-French Laboratory

"Ecology and Sustainable Development": an ARCUS* project 2007-2009

funded by MAEE/Région Languedoc-Roussillon, coordinated by Agropolis International**

Aware of environmental problems, China seeks for alternative models of development

The eco-island of Chongming: a pilot project

The Chinese Government and the Municipality of Shanghai launched a pilot project of an island ecological site integrating ecological agriculture, clean and innovative industries, "green" building, ecotourism... A true model of an ecological and sustainable development and a symbolic event for the 2010 World Expo, it reconciles economic growth and respect for environment.

For a scientific monitoring of this pilot development project, the Shanghai Municipality created the Chongming Ecological Centre for Scientific and Technological Innovation. This centre includes 6 research laboratories, of which a Sino-French Laboratory.

*A.R.C.U.S = Actions en Régions de Coopération Universitaire et Scientifique (International Research Programs co-funded by MAEE and Regional Governments) - **M.A.E.E. = French Ministry of Foreign and European Affairs

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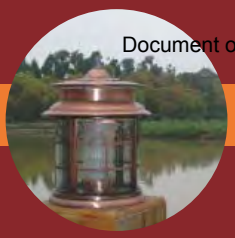
MINISTÈRE DES AFFAIRES ÉTRANGÈRES ET EUROPÉENNES

la Région Languedoc Roussillon

AGROPOLIS INTERNATIONAL



The Sino-French Laboratory in Ecology and Sustainable Development of Chongming eco-island

Origin: rooted in an agreement between the STCSM (Science and Techonology Commission of Shanghai Municipality) and the *Réseau France-Chine Innovation*
French funding: € 900,000 of which € 500,000 from ARCUS* (€ 250,000 MAEE** + € 250,000 Région Languedoc-Roussillon)
Chinese co-funding: € 160,000 in 2007 + ...

15 innovative research programs on 3 main fields

1. Sustainable water management 水

- Strategies for sustainable water management
- Membranes for the treatment of used waters
- Innovative captors for water quality control
- Processes of eliminating micropollutants
- Treatment of used water, an integrated approach
- Management of urban rain waters

2. Energy and waste 火

- Model building with high energy performance
- Transport and storage of energy
- Environment friendly biodegradable materials from recyclable sources
- Nanofibers for analysis, depollution & energy production

3. Ecology and eco-agriculture 土

- Tools for decision, evaluation, visualisation and monitoring of ecodevelopment
- Improving and optimising forest periurban ecosystems
- Increasing biodiversity in periurban ecosystems
- Performant eco-griculture coupling preservation of soil and water resources with carbon sequestration and product quality
- Role of potassium in plant adaptation to drought and salt stress (molecular and electrophysiological analyses

+ cross-cutting actions (education, training...)

French partners

CIRAD, CNRS, INRA, Montpellier SupAgro, Universities of Montpellier (I & II), University of Perpignan, INSA Toulouse, Competitivity Pole DERBI.

Chinese partners

4 universities of Shanghai: Tongji, Jiao Tong, East China Normal, Fudan + Shanghai Institute of Ceramics (Chinese Academy of Sciences)

A model of research for development and also a cooperation model

This inter-institutional and interdisciplinary project enhances synergy between chinese and french teams. It combines research, training and technological transfer. It emphasizes the large potential in multisectorial cooperation between the Languedoc-Roussilllon Region and the Municipality/Province of Shanghai. As a symbol of a regional action within a national framework, it could also become a gateway for scientific, educational and economic exchange between the two countries.

CONTACTS
In France: Paula DIAS, dias@agropolis.fr
In China: Fengting LI, fengting@mail.tongji.edu.cn
More at: www.agropolis.fr

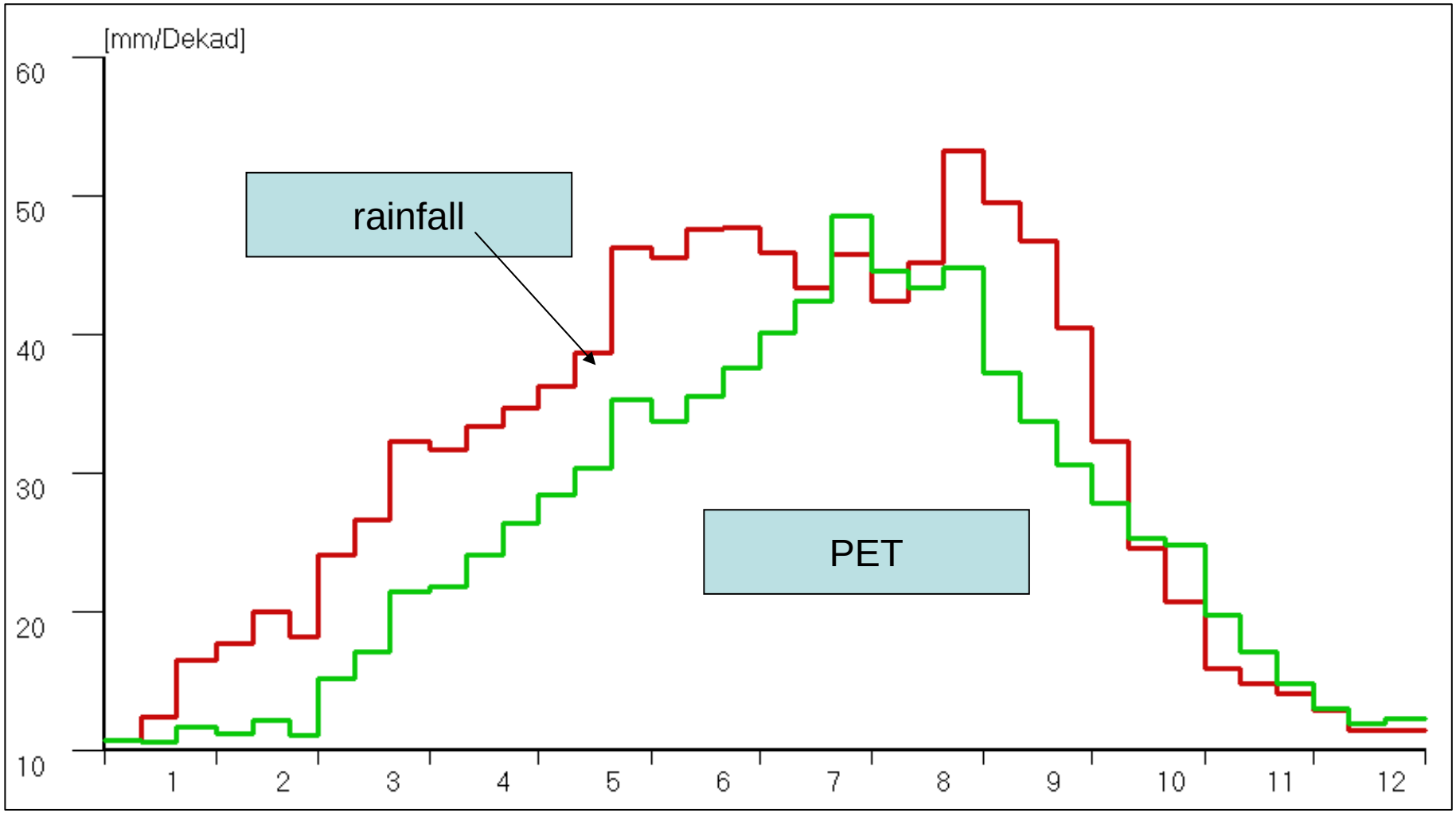
ANNEXE IV

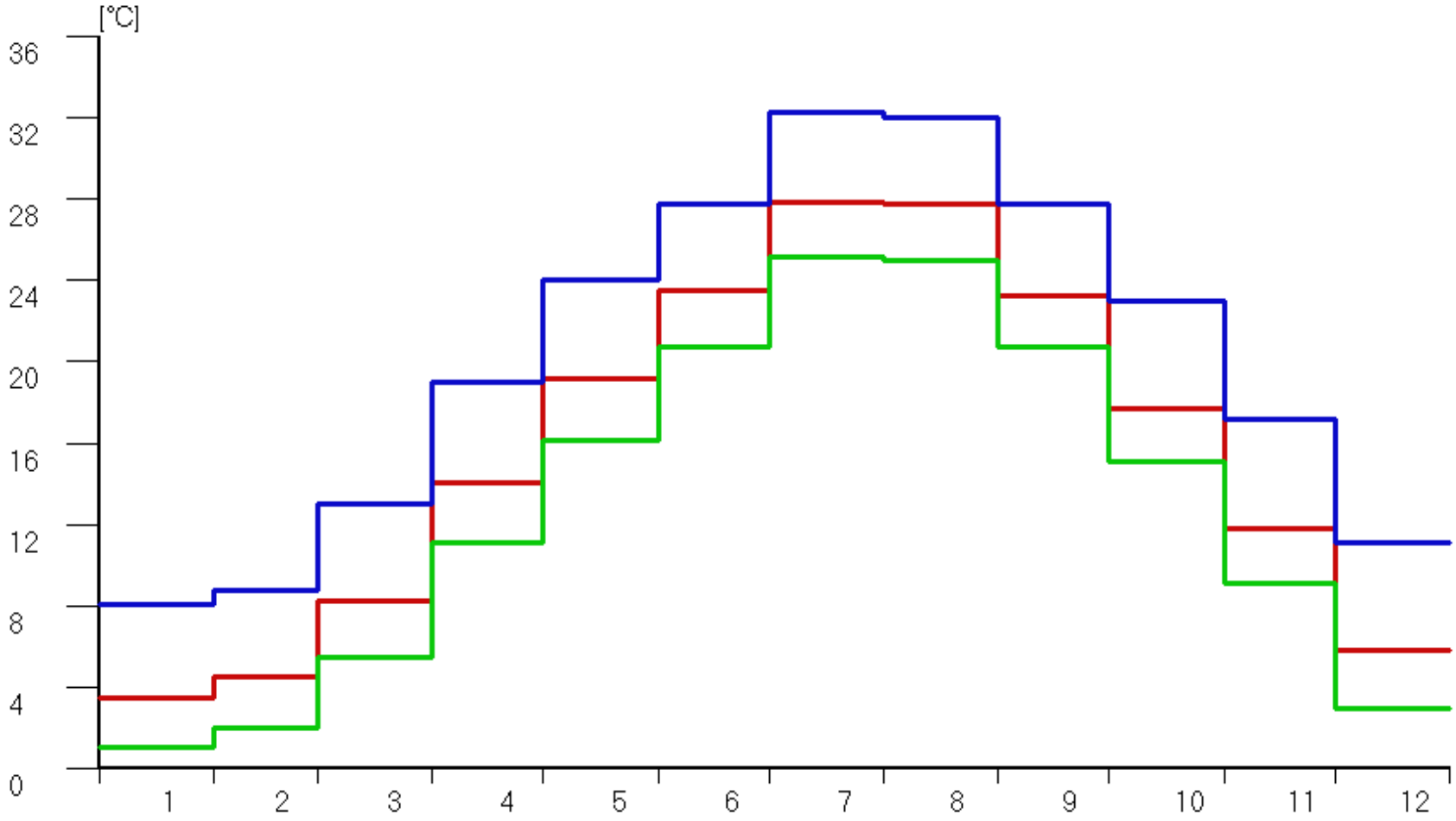
Initiative ARCUS – AGROPOLIS
SUBPROJECT III Ecoagriculture
Chongming island
JIAO TONG University Shanghai
DMC CIRAD
March 2009

Latitude

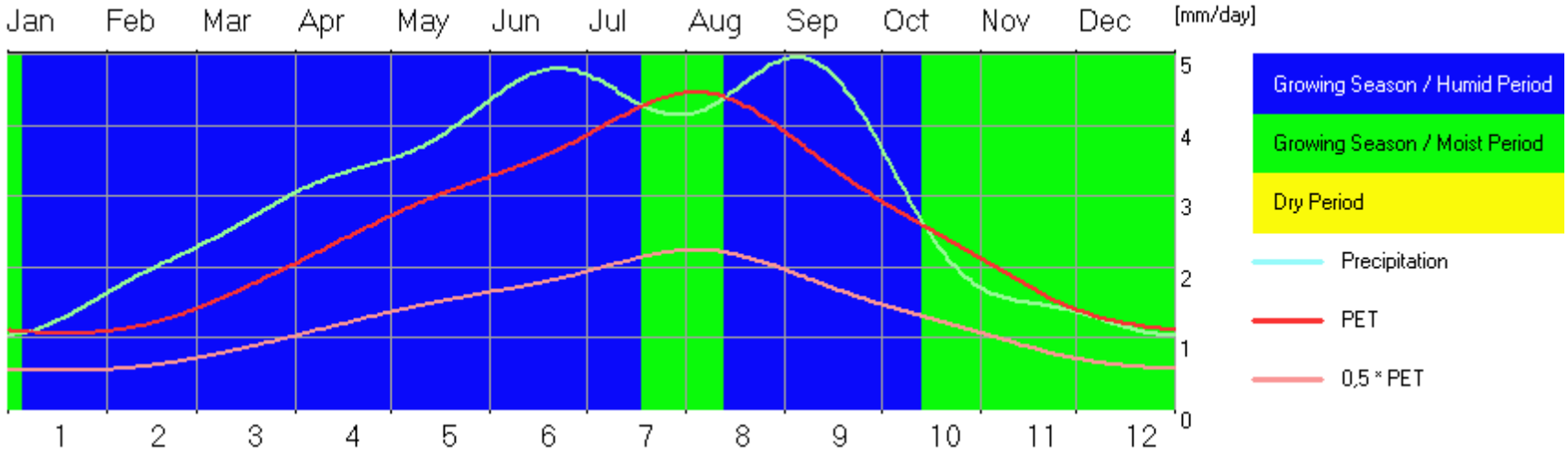
PEDOCLIMAT

- **All Chongming soils are developed on alluvial mother materials. They are Sandy soils, pH is basic around 8,0-8,5 pH. It is saline soils because of saltwater intrusion. Some agriculture soils show a secondary salinity because of fertilisers overuse and irrigation. The water level into the soil is almost between 2 and 3 meter. Water content increases with depth. Behind 40-50 cm the soil is highly satured in water, texture is striggy.**





T℃ max mean & min



RICE growing period

2 sites d'observation et test preliminaire

- Fertile soils
- Mainland

Saline soils

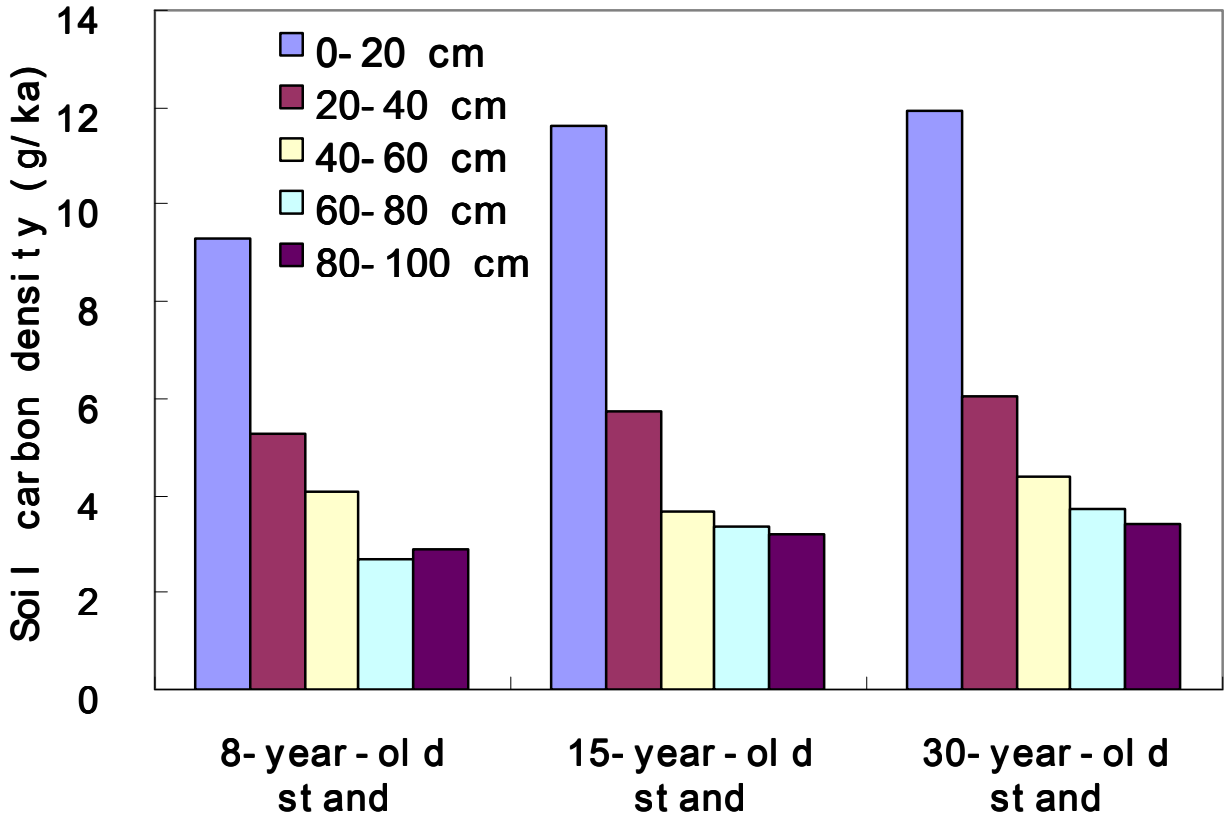
Chong minh

- **Ph 6 – 7**

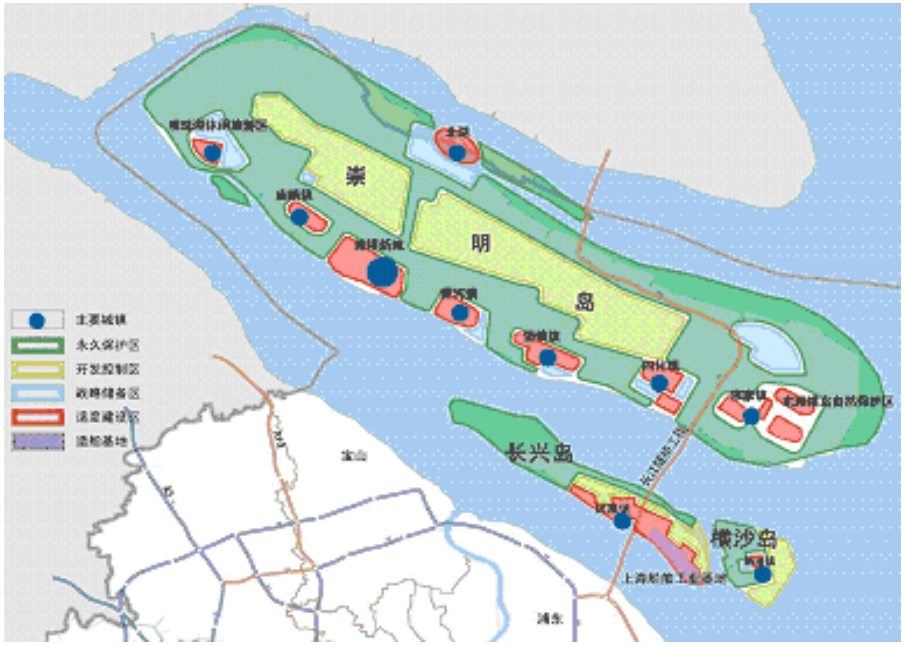
Ph 8 - 9

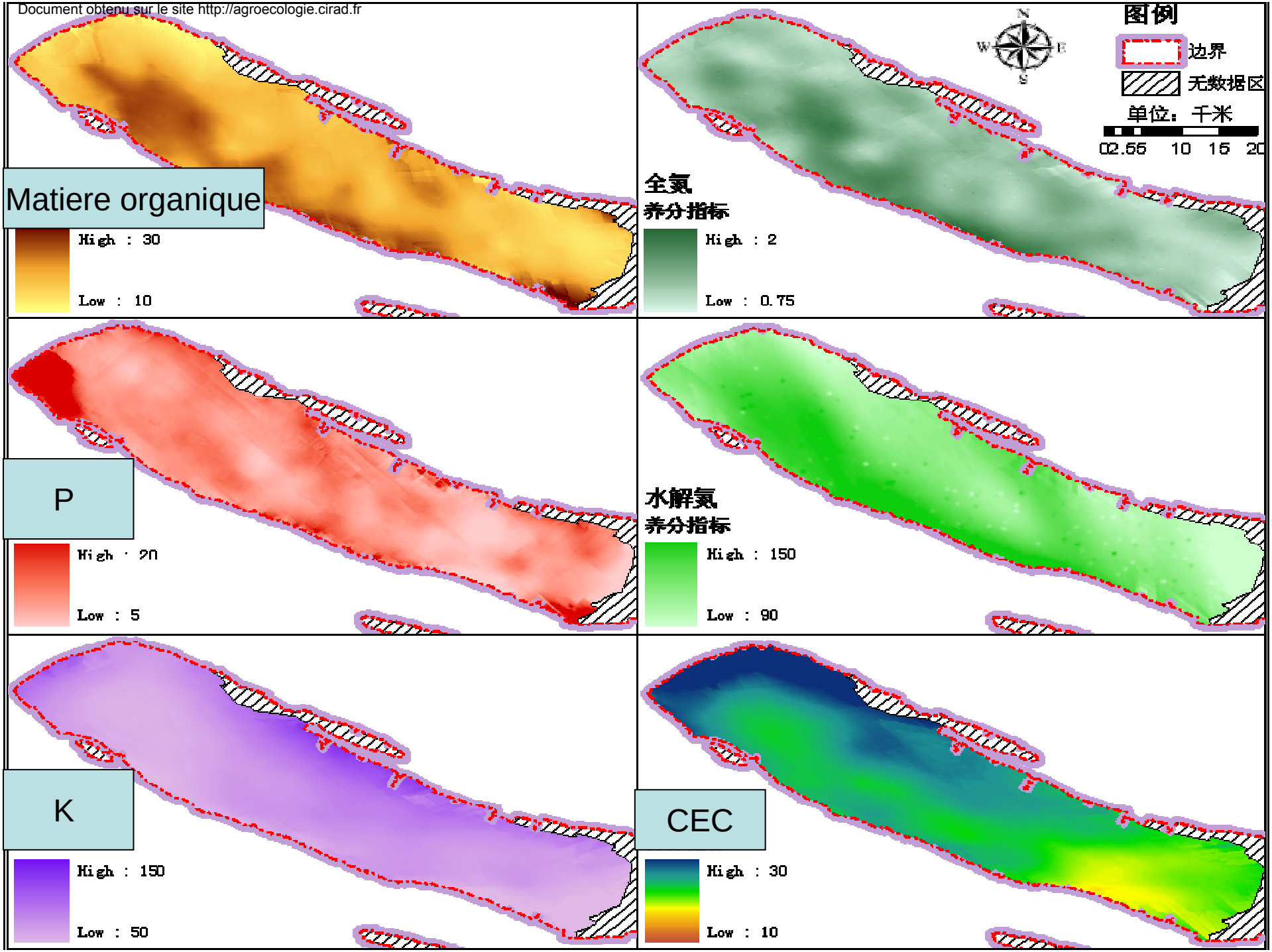
Saline soils in Chongming and agroforestry

Ages (yr.) of trees	Soil layers (cm)	Bulk density (g cm^{-3})	pH
8	0 ~ 20	1.55	8.47
	20 ~ 40	1.59	8.31
	40 ~ 60	1.59	8.29
	60 ~ 80	1.55	8.27
	80 ~ 100	1.51	8.11
15	0 ~ 20	1.62	8.39
	20 ~ 40	1.66	8.37
	40 ~ 60	1.60	8.25
	60 ~ 80	1.57	8.17
	80 ~ 100	1.54	8.22
30	0 ~ 20	1.62	8.48
	20 ~ 40	1.63	8.59
	40 ~ 60	1.44	8.31
	60 ~ 80	1.44	8.24
	80 ~ 100	1.44	8.20



Chongming Island in China





Towards a productive and ecological agriculture

In many tropical countries, no till **D**irect seeding **M**ulch based **C**ropping **DMC** systems[1] are being considered as a viable alternative to restore degraded soils. The Arcus sub-project 3 will study how these no till systems in the case of ecofarms in Chong Minh island may allow an increased biological activity within the soil, restoration of soil fertility, crop's productivity (rice, corn…)and soil biodiversity: mesofauna, microflora…

Context

The negative impacts of conventional agricultural practices are well known : land degradation, soil erosion, decline in biodiversity, pollution, desertification, etc.) in addition to all of their dramatic social implications. Global food needs are rising with population growth. Agricultural production has to be increased to fulfill these pressing needs. Agricultural systems capable of meeting this challenge must now be productive,profitable and sustainable, increasing production and the quality of products, boosting farmers' income, while preserving natural resources and the environment.This objective may be met through a scientific approach named ecological intensification where the soil is recovering its native multifonctionalities.

Soil destruction under till agriculture (Laos)

What are DMCs ?

DMC is a soil no tillage agricultural approach that has short - to medium-term effects with respect to water conservation, halting erosion, increasing soil fertility, stabilising or even increasing yields, even on infertile wastelands, while also reducing labour and fuel consumption. This innovation is based on three concepts that apply in the field, i.e. no tillage, permanent plant cover and relevant crop sequences or rotations associated with cover crops.

How do they work ?

These techniques involve sowing crops directly in permanent biomass cover (residues from the previous crop that has been left on the ground or fresh mulch directly obtained from a dried cover-crop (use of machine or minimum herbicide). This biomass coverage protects the soil, increase infiltration of rainfall and nourishes microorganisms that vitalize the soil and enhance its fertility. The use of strong-rooting efficient plants (restructuring fibrous root systems of grasses, powerful taproots of atmospheric nitrogen fixing legumes) in cropping sequences promotes impressive 'biological tillage' of the soil in conjunction with the work of earthworms, which are in turn preserved because of the absence of any perturbation (tillage).

Where are they used ?

In 2005, 95 million ha were cropped under direct seeding systems worldwide. DMCs are mainly implemented on a very large scale in Brazil (almost 24 million ha in 2005).

Through the initiatives of CIRAD (L. Séguy et al), they have also being adapted to small-scale farming conditions in tropical countries as *Cameroon, Laos, Madagascar, Cambodia and Vietnam*… etc.

DMCs can be promoted and adapted under most socio-economical and agroclimatic conditions all over the world. Morever, it is even possible to recover land that has been left idle (wasteland) after years of mining tillage.

Beans and rice on maize residues
Maize on Centrosema spp

Credits : Cirad DMC Unit
http//www. cirad.agroecologie.fr

What are the benefits of DMCs ?

DMCs offer major agricultural, environmental and socioeconomic advantages:

• From an agroenvironmental standpoint,

DMCs halt soil erosion which is responsible for waterlogging and destruction of crops and downstream infrastructures (very costly hydroagricultural structures, roads, ditches). By restoring the plant cover, they control runoff, stimulate biological activity in soils, reduce water needs and sequester carbon in the soils (1-2 /ha/year of carbon, depending on the ecosystem and fertilizer input) helping to mitigate climate change. DMCs also is reducing diseases and pest pressure on most crops under all soil-climate conditions.

Under performant cover crops management, minimum to zero use of molecules is usefull for weed control

• From a socioeconomic standpoint,

DMCs markedly reduce weeding and tillage operations, as well as associated labour and equipment costs. Yields are stabilised or even increased under a broad range of climatic conditions and cropping systems. Moreover, DMCs do not require large equipment such as tractors or treatments with massive quantities of fertilizers or herbicides. DMCs can be implemented by smallholders with just 0.25 ha of land or owners of large-scale plantations!

Why do these techniques interest the farmers ?

DMC techniques are very popular amongst adopting farmers due to the possibility of increasing their income, reducing laborious work and labour time, enhancing biodiversity, thus boosting their food and economic security. The personal benefits, and primarily the increased yields and financial savings, are highly attractive features for farmers. They may also be attracted by the overall benefits for society and the environment, but these aspects are chiefly of interest for governments and the international community (Kyoto Protocol, land management, etc.). DMCs are compatible with all types of mechanization, from simple hand tools to precise agricultural machines, so farmers of all socioeconomic categories are thus concerned. Special equipment has been developed for a range of farming systems. Many plants have already been identified as efficient cover species, and may be adapted to different soil-climate conditions worldwide.

From pathways, high run-off is collected with no erosion in the DMC fields

How are DMCs created and disseminated

In a first step, field agronomists with the support of soil scientists have to show the performances of the innovant DMC System.
In our case of Chongminh Eco Lab project, rice - corn - soybean oriented DMC systems mixed with C4 & C3 cover crops are suggested.

In a second step, DMC technology may be quickly adapted to specific on farm context by volunteers and champions farmers acting in close contact with agronomists having the expertise.

During the first 3 years, adopting farmers require constant supervision from the outset to facilitate their perfect handling of these techniques. The public as the agrobusiness sector (Chinese rice company in our case) should promote access to information, specific training on these new farming practices.

Towards a new paradigm

When farmers adopt DMC, major changes are necessary in their crop management patterns (fields) and in the organization and management of farms and the agrarian region. DMCs are relatively complex from a technical and intellectual standpoint—these new agricultural paradigms require relatively long development and adaptation periods, a substantial stakeholder network and major changes in peoples' strategies and priorities, which may take a few years or as long as one or two generations. DMC is not simply a technical package that can be disseminated, it is a set of practices, methods, systems, etc., and the changes cannot be made from one day to the next ! The change process may also be hampered by cultural and social barriers due to tight attachments to conventional farming practices (with tillage, 'clean' fields, etc.). This represents a major change in mindset for farmers, as well as for other associative, political and institutional stakeholders.

Need for research to explain the DMC Rice system functionning and to prepare the future improvement of sustainable Rice production and its quality in saline soils

- Rapid effect of DMC practices on soil physical chemical and biological properties are necessary yearly from year (0) to the termination of the project. As an example, carbon sequestration in soil will be studied.
- Soil biodiversity (structural and functional) analysis is mandatory for explaining the long term impacts on soil productivity and resiliency..
- Introduction of new rice cultivars will boost the soil crop productive interactions and will allow significant increase of land productivity
- A full survey of risk of parasitism, soil born diseases… will allow to study the role of biological activity on the self tolerance or crop's resistance to diseases vectors under DMC practices compared to conventional one.

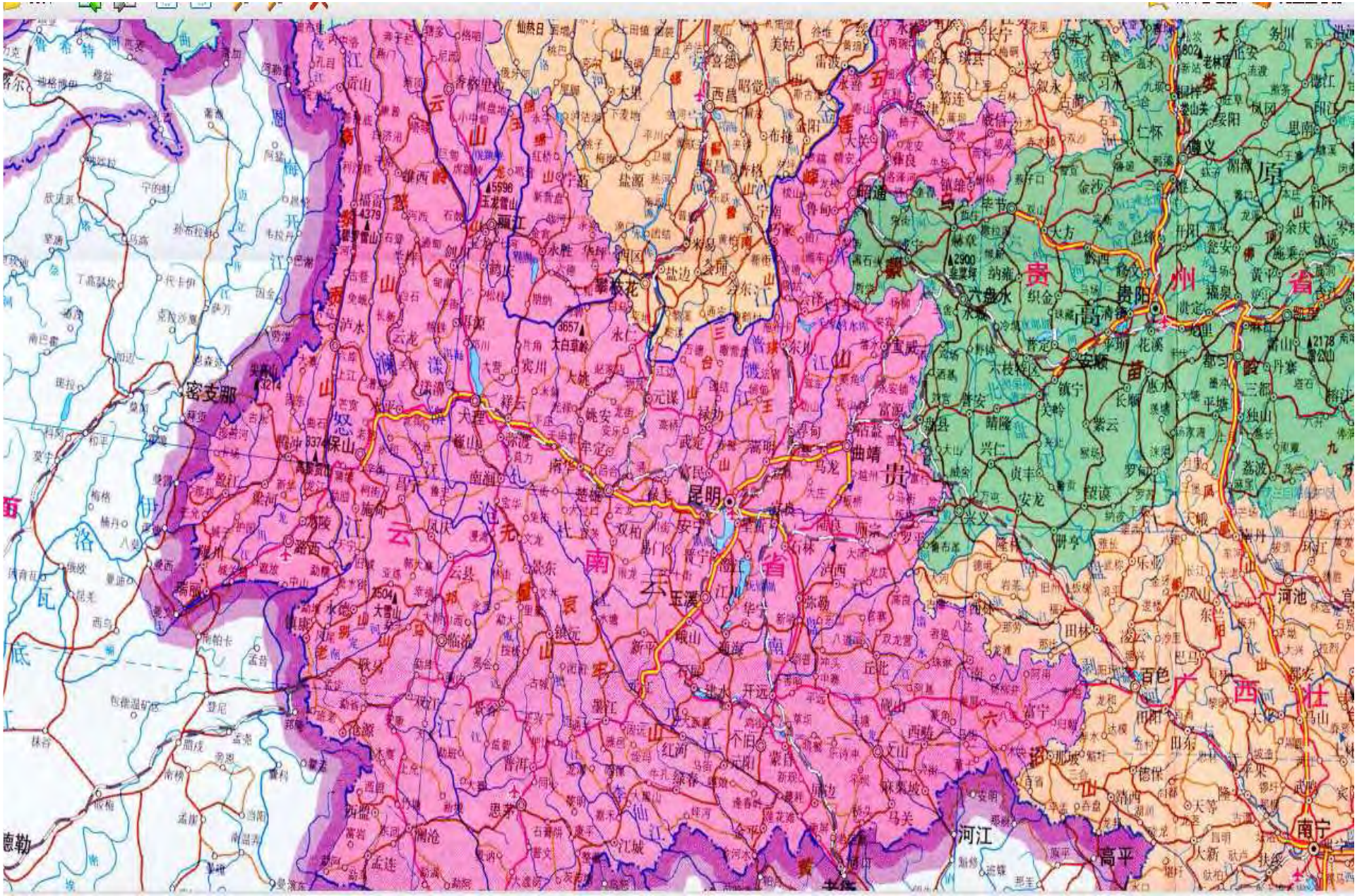
ANNEXE VI

Key-Technology Research and Demonstration of Agricultural Sustainable Development in Mountainous Area in Southern Yunnan. Based on Sino-France Cooperation (“SIFROSA” Project)

Yunnan Academy of Agricultural Sciences, Agricultural Environment and Resource Institute (“YAAS-AERI”)

12, March 2009

Yunnan Province, China



Why Southern Yunnan is Chosen for?

1、Peculiar Character：mountainous A200Tkm2 M90%

Poverty 17M income≤210＄ N460 ＄

Minority 21

Frontier 4061km

Its position in the Greater Mekong Sub-region (GMS)

Why Southern Yunnan is Chosen for?

2、Fine Natural conditon

Average T	**15—22℃**
Rainfall	**700—2000mm**
Altitude	**76.4-3000m**
agro-ecological diversity	**very broad**

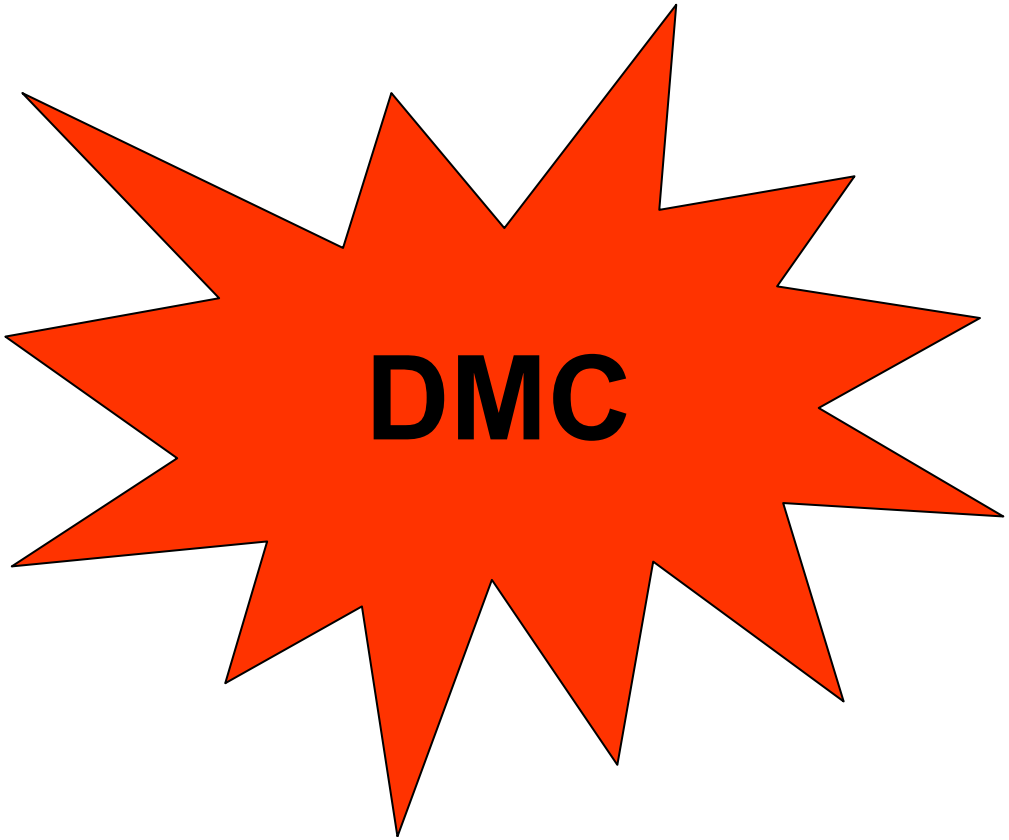
What is main Constraints

As expressed by farmers in PRA

- Severe soil erosion
- Lack of water
- Sloppy lands
- Costly inputs
- Lack of knowledge about new technologies

What is the solution

DMC is the effective method for farmer choice, especially the conservation agricultrue is raisen as a strategic policy for agriculture developing in china



How to do?

Developping sustainable agriculture in southern mountainous ,Yunnan,China

Key point is

Direct mulch-based cropping system (DMC)

What to do

IRRIGATED MOUNTAINOUS paddy FIELD

RICE—SOYBEAN—POTATO CROPPING SYSTEM, AND APPLIED THE DMC.

RAINFEED MOUNTAINOUS dry land

MAIZE--SOYBEAN CROPPING SYSTEM, AND APPLIED THE DMC. SMART MACHINE BE INTRODUCED AND BE APPLIED ALSO

TEA /LEMON INTERCROPING WITH PINTOI PEANUT OR SOYBEAN OR PEANUT etc ,DMC IS APPLIED.

What to do

2. Specific objectives

To research key technologies of agricultural efficient sustainable development in paddy fields;

To research key technologies of agricultural efficient sustainable development in dry land;

To research key technologies of efficient sustainable development for dry land economic crops

What index will be assessed

1 15 covering material be introduced,and 2 be applied in production; 6 local herb be tested ;3 food variety or cash crops be extended

2 Build up 4 produce model for farmers choosing;such as “rice-soybean-potato”and DMC、“Lemon-pintoi peanut” etc.

3 Set up 530ha demonstration field, in which each farmer income be increased 30 $

4 3 Ms or Doctor should be trained, 50 farmer technician be trained also; 5Paper be published

Responsibilities and obligations for two parties

(1) Responsibilities and obligations from YAAS-AERI

Evaluating screening,renovating and using the introdued crops germplasm;

Evaluating screening,renovating and using introduced key technologies of sustainable development of mountain farming

Evaluating and using economically the key technologies of sustainable development of mountain farming

Supplying the conditions of life and work for scientist and personnel from CIRAD

Requisitioning funds of research development and training in china

Responsibilities and obligations for two parties

(2) Responsibilities and obligations from CIRAD

CIRAD will provide key crops DMC oriented germplasm for YAAS in accordance with relevan country legislation;

CIRAD will provide knowledge, know how and informations on advanced key technologies o sustainable development of mountain farming and small farm machineries for YAAS;

CIRAD will contribute to the carrying out of a synthesis of the socio economic of the constraints for agriculture in the southern Yunnan, based on available and updatec information.

CIRAD will train technologically (case of DMC technology) the Chinese researchers;

Along with YAAS, CIRAD will participate to the conception of a larger dimension project or sustainable agriculture, to be presented for funding by national, European and/or internationa financial backers.

CIRAD –PERSYST duty in SIFROSA project

1 Introduce 10 covering material into Yunnan for project
2 Training DMC for technicians and guide the technology 50
3 Introduce 2 smart small machines which adapted the DMC demonstration
4 Help 4 members of project team to be short trained in abroad or participate the international congress
5 CIRAD scientist should total work in Yunnan for 60 days during the project ,and the life and working cost by supported by YAAS
6 Promotion the CIRAD-YAAS “center” being set up
7 Do best for applying the project and get the funding from different channels

OTHERS

SIFROSA “RESEARCH AGREEMENT” which was signed by two parties in Oct 2008 in France

ANNEXE VII

Agenda of ARCUS Project Action 3

March 8 Sunday

Noon, French colleagues (Francis Forest, Lucien Séguy, Jonny Boyer, Group 1) arrive in Shanghai

March 9 Monday (for group 1 and 2)

5:30 4 Chinese colleagues (LIU Chunjiang, LI Yinsheng and 2 master students, one of whom is from Shandong Qingdao Agricultural University) depart from Shanghai Jiaotong University by minibus

6: 30 Minibus arrive at Shanghai mansion hotel to pick up French group1 (FF, LS,JB)

6: 40 Minibus arrive at Shanghai Xingleting Jinqiao hotel to pick up French Group2(MS,PD)

(**: Please have a breakfast yourself before departure, we haven't time for it during the trip. Sorry!)

7:10 Arrive at Shidongkou ferry port

7:10-8:30 ferrying

8:30-9:30 Visiting DMC alternative test plot 1

9:30-10:30 Visiting DMC alternative test plot 2

10:30-11:40 Visiting Dongping forest (or other point?)

11:40-13:00 Lunch

13:00-14:00 Visiting Qiangwei Eco-village

14:00-17:00 Visiting Dongtan wetland

17:00-17:30 Back to ferrying port of Chongming from Dongtan

17:30-18:50 ferrying

19:10 arrive at hotel

March 10 Tuesday (for Group1)

8:30-9:30 French colleagues take taxi to Jiaotong University.

9:30-10:30 French and Chinese colleagues tank taxi to Qingpu

10:30-11:30 Visiting Qingpu DMC test plot, discuss with Landowner

11:40-13:00 Lunch at Qingpu

13:00-14:30 Trip back to Jiaotong University by taxi

14:30-16:00 Discuss test design of DMC

16:00-17:00 French colleagues take taxi to the meeting with consulate

March 11 Wednesday (For group1 and 2)

8:30-9:30 French colleagues take taxi to Jiaotong University.

9:30-11:40 Visiting experimental farm and labs of Jiaotong University.

12:00-13:30 Lunch

13:30-15:30 Discuss budget of the DMC test.

15:30 French colleague take taxi back to hotel

…….Kunming……..

Visiting schedule for Dr. L. Seguy and F. Forest in Kunming, Yunnan

No.	Date	Time	Arrangement	Participants	Vehicles arrangement	Place	Hotel	In charge
1	11/3(Wed.)	Depart from Shanghai to Kunming (Flight No. CZ6799) and arrive at 23:20	To welcome Dr L. Seguy and F. Forest at the airport	Hongye Zhu, Baokun Lei (Depart from Jiangan to the airport at 22:20)	AERI 云 A.PA286 Zegui yang 13759475768		Best way Hotel	Baokun Lei 13759542621 Shoujia He 13619680562
	12/3 (Thurs.)	8:30	Depart from the hotel to AERI					
		8:30-9:30	To visit the experimental building of AERI. Mr. Aidong sheng introduces AERI	Aidong Sheng(AERI Director), Baokun Lei, Shufang, liu		AERI		Aidong sheng 15825288855
		9:30-11:30	Experts of CIRAD academic report and discussion	Researchers of AERI and FCI		Meeting room of AERI at the third floor		Hongye Zhu 13708867826
		12:00-14:00	Lunch	CIRAD experts, Aidong Sheng, Hongye zhu, Lingming kong, Baokun lei, Shufang liu *et al*	AERI: Zegui yang 13759475768 云 A.PA286, SRI: Jiansheng qin 2234941 云 A.GV126	Fuzhaolou restaurant		Shufang liu 15808762016
		14:30-15:30	Discussion on the content, plan and division of the project	CIRAD experts Hongye Zhu, Baokun Lei and participants of the project		Meeting room of AERI at the third floor		Hongye Zhu 13708867826
		15:30-15:45	Coffee time			Third floor balcony of AERI		Yanhua Pan 13577049859
		15:45-17:30	Discussion on the co-constructing of a research centre and the visiting schedule of CIRAD director in YAAS	CIRAD experts, Dayun Tao, Lichi Li, Aidong Sheng, Hongye Zhu, Baokun Lei, Shufang Liu		Meeting room of AERI at the third floor		Lichi Li 13888011836

No.	Date	Time	Arrangement	Participants	Vehicles arrangement	Place	Hotel	In charge
		18:00	Banquet	CIRAD experts, Mr. Dai(Director of YAAS), Hongye Zhu, Dayun Tao, Baokun Lei, Lichi Li, Lingming, Kong	AERI(1) and SRI(1)	Dashijie cross bridge rice noodle city	Best way hotel	Baokun Lei 13759542621
3	12/3 (Thurs.)	12:45 Depart from Beijing to Kuning	To welcome Zheng Li at the airport Arriving time: about 16:10	Lichi Li			Best way hotel	Lichi Li 13888011836
4	13/3 (Fri.)	8:30-12:30	On the way to Wenshang county Distance: 300km Lunch at 12:30	CIRAD experts, Hongye Zhu, Baokun Le	AERI(1) and SRI(1)	Meeting room of Wenshan institute of agricultural science and a field	Jiulong hotel	Baokun Lei 13759542621
		15:00-18:00	To visit Wenshan no-tillage mulch experimental fields of crops	CIRAD experts, Hongye Zhu, Baokun Lei, Mr.Yun Li(Vice director of Wenshan Institute of Agriculture Science)				Yun li 13887639990
5	14/3 (Sat.)	8:30-12:00	On the way to Honghe county Distance: 150km Lunch at 12:00	CIRAD experts, Hongye Zhu, Baokun Le		Meeting room of institute of silkworm and bees and a field	Rest house of institute of silkworm and bees	Ping huang 13887355795
		15:00-18:00	To visit Honghe no-tillage mulch experimental fields of mulberry garden	CIRAD experts, Hongye Zhu, Baokun Lei, Mr. Ping Huang(Director of the Institute of silkworm and Bees)				
6	15/3(Sun.)	8:00-12:00	Depart from Mengzi to Kunming. Depart from Kunming airport at 13:30 (Flight No. MU 751)	Hongye Zhu, Baokun Lei				Baokun Lei 13759542621