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Mountain Agrarian Systems

A participatory simulation to facilitate farmers' adoption of livestock feeding systems based on conservation agriculture in the Vietnam uplands

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Abstract

Within the mountainous area of Northern Vietnam, conflicting situations exist between large ruminant extensive husbandry, agriculture and forest management, particularly during the winter when there is a lack of animal feed and buffaloes are used for their draft power. Underfed animals exhibit low reproduction, production and labor performances, damage crops and overgraze natural forage resources.

Since 1997, the Mountain Agrarian System (SAM) project implements research activities to develop and diffuse technical innovations based on cropping systems with cover crops (CSC). In this perspective, SAM developed a set of communication tools between farmers and researchers to support the diffusion of these innovations in Bac Kan province.

Among them, a participatory simulation method was developed that combines a compartmental model of the village territory with five technical innovations. We tested it with a group of farmers. They could individually chose some innovations among CSC food-forage crop rotations or annual/perennial, urea treated straw and oats as winter crop. They could then simulate the results in terms of forage provided to their own herd when implementing the chosen set of techniques.

The simulation revealed farmers' constraints and objectives, and the individual results constitute a useful basis for discussion about innovation implementation, oats as winter fodder directly sowed under a rice straw cover and urea treated rice straw being currently practised by a few farmers.

This participatory simulation method could be generalized to facilitate innovation diffusion for integrating livestock feeding systems with conservation agriculture practices.

Keywords: Big ruminants feeding systems, cropping systems with cover crop, spatial land use model, participatory simulation, innovation diffusion, upland agriculture, Vietnam

1 Introduction

Since 1997 the Mountain Agrarian Systems Program has been investigating land use changes and prioritizing development issues in Bac Kan, one of the poorest provinces of Northern Vietnam (Castella et al., 1999). The diagnostic phase revealed three driving forces for local development that are shared by many other upland areas in Northern Vietnam and also in Southeast Asia. First, villagers' accessibility

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to markets, education, health services and technical information is of critical importance in providing diversified local development opportunities. The geographic diversity of the landscape creates a high diversity of socio-economic environments (Donovan et al., 1997). Second, the successive land policies that have accompanied the process of agricultural decollectivization over the last decade have been a major driving force of land use changes (Boissau et al., 2001). Land distribution to individual households profoundly modified land use systems both in the valley bottoms and on the slopes (Boissau et al., 2001a). Third, crop-livestock-forest interactions were completely transformed by a changing economic context, accessibility and land tenure policies. The management of large ruminants has become a major constraint to agricultural intensification in both the lowlands and the uplands (Husson et al., 2001; Castella et al., 2001). Restricted access of buffaloes and cattle from their traditional fodder resources pushes them into the shrubs and forests causing problems for forest regeneration but also to the animals, as their poor diet leads to poor performance (Castella et al., 2001a). Over the recent years major environmental concerns have been raised about the mountain agricultural systems, concerns that emerged after the abolition of the agricultural collectives in 1988. Although our research program could not go beyond documenting the impact of accessibility and land policies on land use changes, we developed a range of technical and organizational innovations to overcome some of the crop-livestock issues that we identified. The former diagnostic study set the stage for the diffusion of the latter innovations.

A large number of cropping systems derived from the principles of conservation agriculture were developed as alternatives to slash-and-burn practices and tested in farmers' conditions (Husson et al., 2001a). They are designed as components of cropping systems that farmers can combine and recombine according to their specific needs and objectives (e.g. priority to rice sufficiency, crop-livestock association, more emphasize on fodder for livestock, perennial crops orientation). The most promising innovations thus far have been (i) direct sowing of upland rice or maize in a mulch of *Brachiaria* (grass) or *Mucuna* (legume), (ii) crop-legume association (e.g. cassava – *Stylosanthes,* orchard-*Arachis*), (iii) vegetative strips (natural vegetation, planted grasses or legumes) along contour lines, (iv) a soil slow burning technique that boosts the fertility of degraded soils by releasing phosphorus in a form that the plant can easily uptake, (v) miniterraces to control erosion on steep slopes. Apart from restructuring soils, erosion control and improved crop management, these innovations can provide good quality forage for their livestock (Eguienta and Martin, 2002).

Although farmers are interested in the proposed techniques, their diffusion is not a straightforward process. We had to consider the specific constraints of the mountain environment in designing our innovation dissemination strategies. In most cases it is impossible for subsistence farmers to adopt a complete package; a **stepwise adoption** (i.e. by introduction of successive cropping systems component) is preferred. The introduction of any innovation is managed in a **systemic perspective**, as changes in the cropping patterns of small upland farms inevitably affect livestock and forest resource management. For example the development of cover crops or vegetative strips would limit livestock access to fallow fields during the winter and would thus require farmers (i) to fence their fields to avoid animal damages to the soil conservation crops, and (ii) to compensate for the restriction imposed on traditional fodder resources by producing forage or providing access to other grazing areas. The integrated components of farmers' livelihood systems cannot be considered or even modified independently from each other. Lastly, with soil and water conservation techniques, the highly diverse upland environment can be used to our advantage. We face a diversity of situations and systems, so we have to offer a **diversity of solutions**. Farmers themselves will choose from among the proposed options to find the ones that best fit their own circumstances and needs.

From a methodological point of view the above constraints to innovation diffusion advocate an integrated approach of farmers' livelihood systems and more specifically of crop-livestock management. But in such a diverse natural and human environment, only a participatory approach could capture farmers' needs in a time effective manner (Castella et al., 2001). The challenge was to engage both scientists and local stakeholders in a mutual learning process. The scientists would facilitate innovation diffusion by providing all the elements necessary for local people to make their own diagnosis about crop-livestock issues, to collectively discover potential solutions and adapt them to the defined issues. To initiate such an interactive communication process we developed a common graphic language between scientists and local stakeholders. The graphic language incorporated two major assumptions derived from previous studies in the same area: (i) the village entity is the relevant spatial and social unit for community-based management of natural resources (Castella et al., 1999a), and (ii) the spatio-temporal dimension of crop-livestock interactions is a key factor to take into account when designing or introducing technical innovations (Castella et al., 2002).

The aim of this paper is to report the experience of using and evaluating the new communication tool as a support to innovation diffusion. The method itself is developed in two specific papers (Castella *et al*., 2002 and 2002a).

2 Test-evaluation of the graphic models

We presented our graphic models to representatives of the local community to verify that we had effectively established a "common spatial language" between researchers and farmers. The common spatial language is intended to provide a concrete support for (i) the participatory validation of local information related to spatial management of natural resources and (ii) the introduction of technical innovations to improve large ruminant feeding systems.

Sixteen farmers attended the two half-day sessions held on 18 and 19 October 2001 at the *Phieng Lieng* People's Committee. They were selected according to three criteria: (i) representatives (men and women) of three main household types classified in a household typology done in Phieng Lieng in 2000 (Eguienta and Martin, 2002); (ii) knowledgeable and influential people within the community; and (iii) farmers who have done experiments with the project and are, therefore, already familiar with the project activities and innovations.

As an introduction to the meeting, the decreasing trend in natural fodder resources and the importance of natural resource management were highlighted. During the first session, a 3-D model of the village (Castella et al., 2002) was used as a visual support to introduce to the farmers the main landscape features and the different land use classes. We established a correspondence between the main landmarks on the 3D model and their representation on a paper-based spatial graphic model. Once the participants were comfortable with the spatial graphic model that represented their village land use in 2001, we used the same kind of graphic standards to represent the land use changes their village underwent over the last forty years. We could thus show that the current land use and related issues are inherited from the past (Castella et al., 2002).

At the end of the first session, a blank calendar (Figure 1) was displayed for the participants to represent the distribution of their activities along one year, by distinguishing the relative contribution of the two genders and the locations of the activities in the village territory. Eight activities were considered: irrigated rice, upland crops, orchard and garden, animal husbandry, gathering of timber and non-timber forest products and off-farm activities. For each activity and gender, the corresponding working period was marked on the calendar. These results from the yearly work distribution among activities and genders are very important because labor force limitation can be a major constraint to the adoption of the proposed innovations. That is why the labor force needed to implement a given innovation as well as the interactions with the other activities all along the year have to be taken into account. Another important result concerns the interactions between crop and livestock related activities, showing among other things that the only forage resources for the animals come from natural resources or rice sub-products:

- After each rice harvest, the ruminants pasture in the remnant field (November - December and briefly in May - June);
- The only forage resource in the cropping area during the buffalo work period is the vegetation bordering the fields and it is not sufficient;
- The farmers have to carefully manage their rice straw stock, which is distributed to the working buffaloes during the second rice season.

During the second session, the spatial model corresponding to current land use was first presented to introduce the spatial compartment model (Figure 1). After the presentation of the different compartments, a graphic scheme was distributed to each participant who was invited to locate his or her own land resources in the different compartments (Figure 2). Then, five innovations were proposed with their corresponding large ruminant feeding capacity. Paper copies of the compartment model were used as supports for a participatory simulation of innovation diffusion at the community level (Figure 3). The farmers were invited to choose among the proposed innovations the one they would adopt, to locate them on the scheme and to calculate, with the assistance of the researchers, the corresponding large ruminant feeding capacity to cover the needs of their herd (Figure 4).

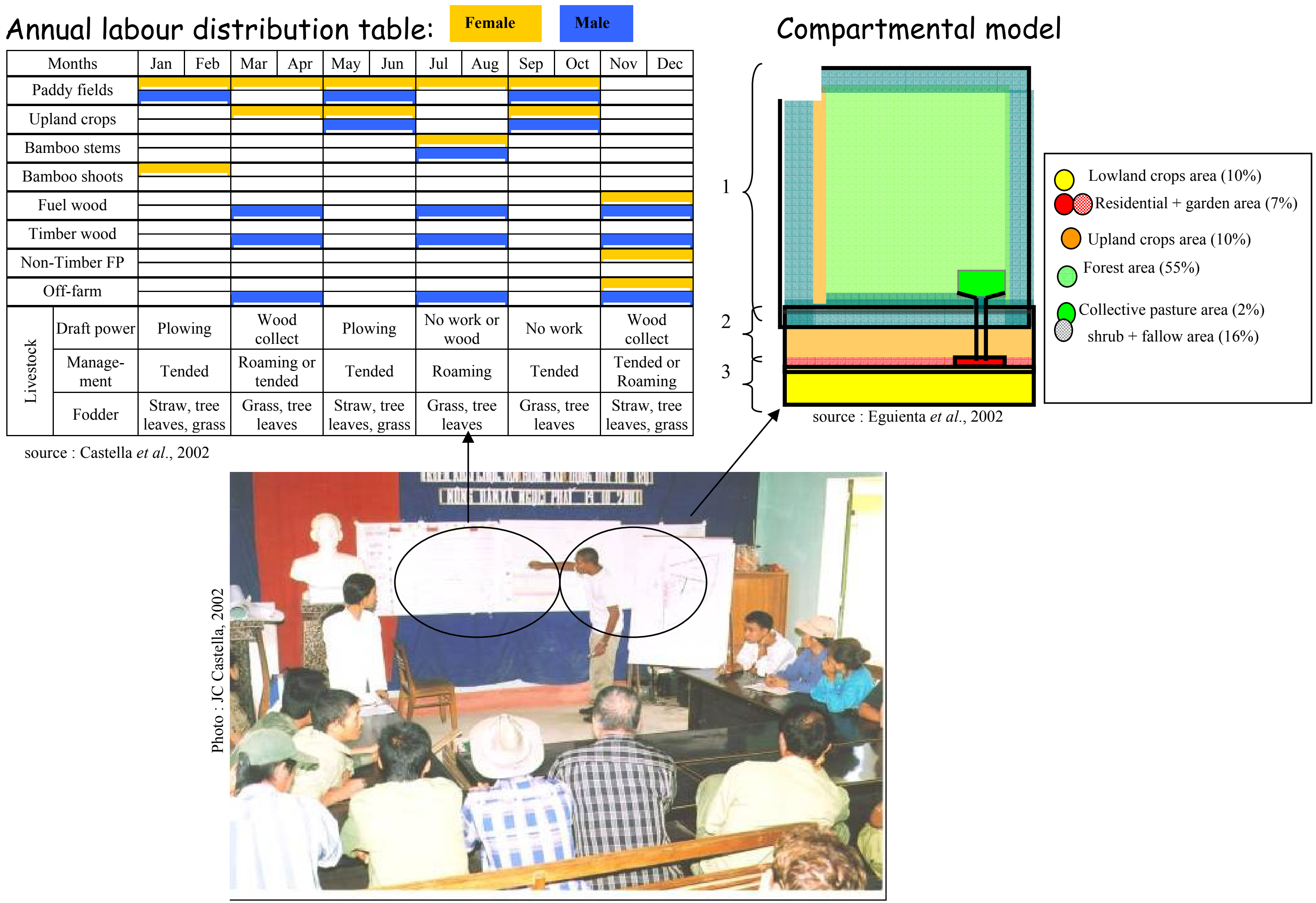


Figure 1: Spatio-temporal dimensions of the simulation

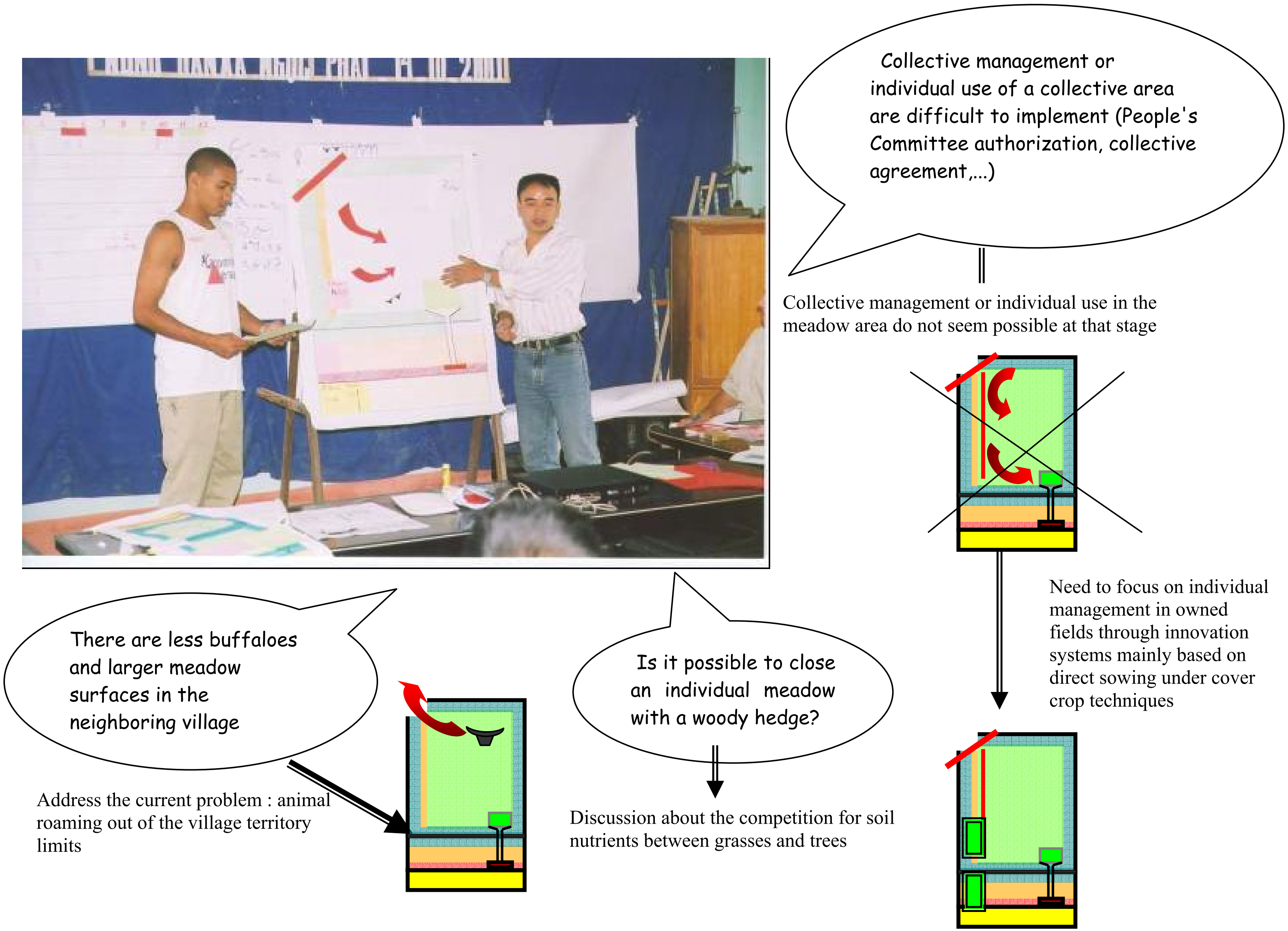


Figure 2: Discussion about a collective livestock management plan

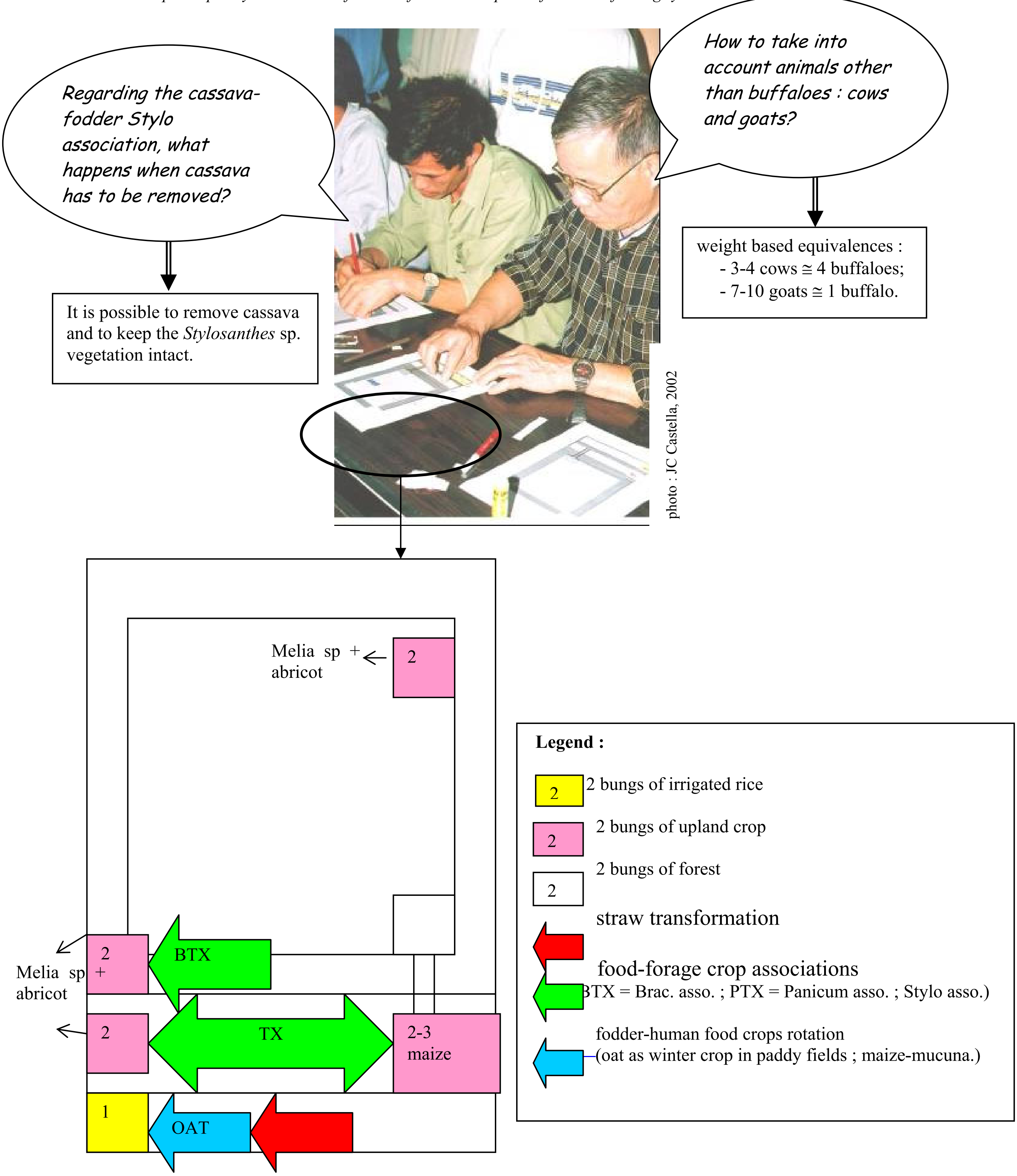
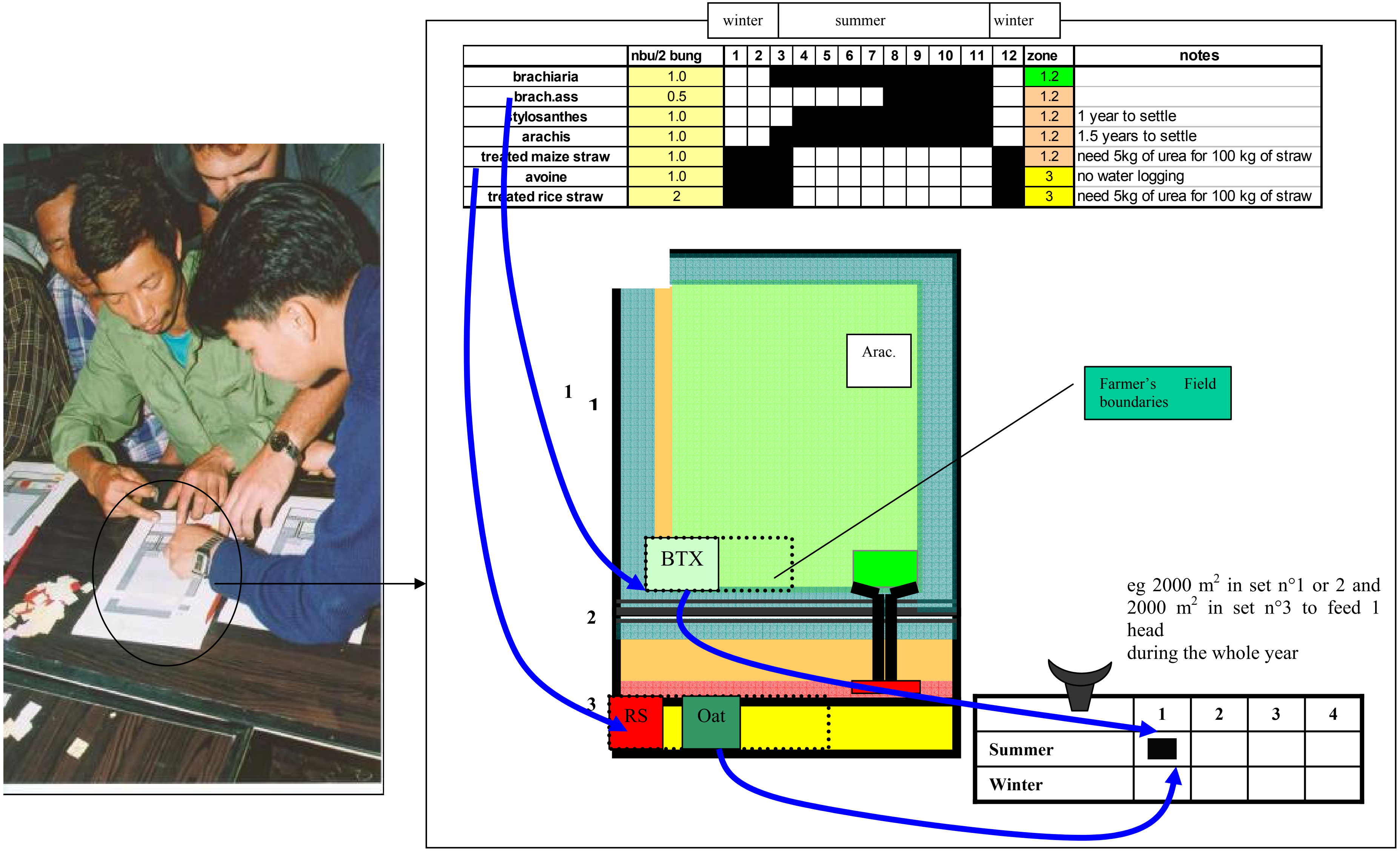


Figure 3: Positioning farmers' resources and innovations on the compartmented model



	nbu/2 bung	1	2	3	4	5	6	7	8	9	10	11	12	zone	notes
brachiaria	1.0													1.2	
brach.ass	0.5													1.2	
stylosanthes	1.0													1.2	1 year to settle
arachis	1.0													1.2	1.5 years to settle
treated maize straw	1.0													1.2	need 5kg of urea for 100 kg of straw
avoine	1.0													3	no water logging
treated rice straw	2													3	need 5kg of urea for 100 kg of straw

Figure 4: Discussions between farmers and researchers about the simulation in term of feeding capacity results

3 Modeling spatial natural resource management at the village level and related livestock management issues

3.1 The compartment model

The different land use sets of the *Phieng Lieng* village territory were drawn from a village level GIS to create a compartmented model (Castella *et al.*, 2002a), where each kind of land use is proportionally represented. This communication tool was progressively presented to the farmers attending the simulation through different versions.

First, the spatial model corresponding to current land use (first level of abstraction) that had been submitted to farmers during the previous session was presented on a paper board. Then, the different elements of the spatial model (Castella *et al*, 2002) were identified and progressively drawn on a new scheme in order to lead the farmers to a second level of abstraction: the compartmented model.

Once the scheme was drawn, a colored version was presented with proportions of land use areas that reflected the real village situation (Figure 1) :

- the lowland crop area corresponds mainly to 1-2 cycle irrigated rice, sometimes maize (hot rainy season) and vegetables (cold dry season) ;
- the garden area is made of vegetables and fruit trees ;
- the upland crop area corresponds to rain-fed rice, maize, cassava and plantations
- the term "forest" groups poor and secondary forests as well as woody re-growth;

Finally, after verifying farmer comprehension, a sheet representing the model was distributed individually to the farmers for the simulation, where they can position their crop and animal resources as well as the chosen innovations.

3.2 Spatio-temporal constraints linked with animal husbandry

Animal husbandry issues take place in the two dimensions of space and time. At the beginning of the 90s, the cooperative herd was distributed to individuals (1 head/person) and then separately developed. The forage resources at the basis of this development are the collective pasture area and the forest. Nevertheless, these areas were not controlled and natural resources gradually became insufficient in terms of feeding capacity, causing two major related constraints:

- lack of forage during the winter (cold dry season): except for dried rice straw to some extent, natural vegetation is the only feeding resource and its growth is near zero. The result is weakening animals, leading to low fertility, abortion, decreased resistance to diseases and low working performance at the beginning of the rainy season (1st cycle rice plowing/harrowing);
- intra- and inter-village conflicts : during the winter, starving animals break fences and damage crops within the village and during the year they pasture in the neighboring village's meadow.

To stress this uncontrolled roaming problem, the village herd movements in the different compartments were illustrated with arrows placed on the model (Figure 2). Then, potential solutions were introduced and discussed:

- closing the access to other village territories : this would be physically very difficult;
- increasing the meadow surface in the collective area : the current surface is able to feed only 12 buffaloes but there are more than 100 in *Phieng Lieng*. Increasing the meadow surface would require collective management or individual disposals on the collective area, neither of which are considered feasible by the farmers at the moment.
- individually implementing large ruminant feeding systems by combining all along the year innovations based primarily on direct sowing under cover crop techniques (CSC) : this solution has been acknowledged by the farmers who agreed to simulate the results of such systems.

4 Simulating the result from large ruminant feeding systems mainly based on cropping systems with cover crop

4.1 Functioning of the simulation

There are two simulation inputs:

- innovation adopted: each innovation has an associated yield and period (winter or summer)
- surface area: the local unit is the *bung* (1000m^2); 2 *bungs*, the area of an average plot, were chosen as the unit surface area.

The output is expressed by the number of equivalent buffalo (equ.bu) per unit surface. The average weight of a buffalo is 300 kg and its daily food requirement is 2,5 kg dry matter (DM)/100 kg. In order to take other animals into account, a cow is estimated as 2/3 equ.bu and a goat 1/10 equ.bu.

4 parameters are considered:

- Potentiel yield[1], expressed in kg/ ha (PY)
- Production period, expressed in days (PProd)
- Consumption rate for a given fodder, ranging from 0 to 1 (CR)
- Daily theoretical maintenance needs for 1 equ.bu, expressed in kg DM/equ.bu/day (MN)

For an innovation and a 2 *bungs* unit surface:

PY*CR / (PProd*MN) = n equ.bu

4.2 Organisation of the simulation

Positioning farmers' resources on the model

Colored squares and arrows symbolizing the farmers' resources were explained and then distributed to the farmers who placed them in the corresponding compartments and discussed them (figure n°3).
Once the attendants located their resources, the exercise was verified with a synthetic table of each attendant resource, established from survey information.

Presentation of the innovations

Five types of innovations have been considered, each one specific to an agro-ecological unit (or compartment), a type of plant and a given transformation level:

① Food-forage crop rotation (e.g. 3 years *Brachiara sp*/maize): allows feeding of 1 buffalo/unit surface from March to November.

② Food-forage crop association:

- *Brachiara sp.* (interlined)-maize allows feeding of 0,5 buffalo/unit surface from August to November;
- *Stilosanthes guyanensis*-cassava or orchard (perennial system, 1 year settlement and weeding required) allows feeding of 1 buffalo/unit surface from March to November.

③ Orchard soil covered by *Arachis pintoï* (perennial system, 1 year settlement and weeding required) allows feeding of 1 buffalo/unit surface from March to November.

④ Urea treated straw, allows feeding (on a 100 kg of straw transformed/day basis) of:

- 1 buffalo/unit surface from December to March for maize straw;
- 2 buffaloes/unit surface, same period for rice straw.

⑤ Winter oats in the irrigated rice fields allows for the feeding of 1 buffalo/unit surface from December to March.

The innovations were presented with a table (Figure 4) indicating the output (equ.bu/unit surface) within the production period and the specificities (settlement time, fertilisation and labor requirements, etc.), and illustrated by photos.

For the buffaloes, an additional table was distributed to mark the size of the herd (Figure 4).

Choice of innovations by the farmers and estimation of results

The graphic symbols corresponding to the different innovations were explained and then distributed to the farmers who chose some (or all) of them and placed them on the relevant compartments of their scheme.

A brief demonstration showed them how to calculate the number of buffaloes fed during the different periods of the year. The result was then reported on the buffalo table.

To complement the demonstration, it was highlighted that:

- the feeding capacity related to the innovations is only estimated and can change in reality;
- only the simplest and cheapest techniques were presented, and they are not sufficient to feed all the buffaloes if we consider the whole of village territory: 70 heads in summer and 50 in winter;
- the calculation does not take labor requirements into account at that stage and corresponds to an upkeep but not a production objective.

[1] Yields are estimated from experimental results obtained by SAM project in 1999 and 2000 and literature (FAO) ; reference yields correspond to minimum values obtained with a low inputs level, on poor soil, in order to be realistic and highlight the constraints ; information about yield has been complemented during the discussion with fodder values, distinguishing between protein and energetic fodders and considering agricultural conservation properties : soil restructuring and protection by *Brachiaria* sp., nitrogen provision by legumes…

The farmers were then invited to make the calculation for their specific situation, with the assistance of the team, and to report the result on their own table, enabling them to visualize if their whole herd can be fed or not and to discuss about it (Figure 4). At the end of the session they were reminded that it was a first step in their problem resolution and encouraged to contact the team if they wished to implement the proposed innovations.

5 From simulation to action...

5.1 Understanding and discussing the model and proposed innovations

Follow-up visits (two sessions totalizing 5 days surveys, from the end of November to the beginning of December) were done with *Phieng Lieng* farmers who attended the simulation.

The aim was to maintain the interest in innovations initiated by the simulation, and to check their comprehension of the model and to get their points of view about the feasibility of such innovations. The surveys were conducted as open interviews to gain the following information:

① Kinship of individuals[2]

② Commenting about the last meeting;

③ Model comprehension testing: Before discussing about the innovations the farmer is interested in, he was asked to describe the three main compartments of the model, the location of his resources and the chosen innovations, in order to test his understanding of the model and to clarify it;

④ Discussing about the chosen innovations (constraints, comments, plans, etc.).

All the people interviewed expressed positive reactions to the meeting. They welcomed the innovations proposed by the project; especially some farmers who want to develop animal husbandry.

Most of the visited participants correctly understood the model and the simulation game. This result confirms their interest and concentration during the model testing. The main comments about current farmers' comments, plans and constraints according to possible innovations and their applicability are presented below:

The diversity of situations can be analyzed through different types of farmers (Eguienta and Martin, 2002). Comments, intentions and constraints revealed through these feedback surveys are presented synthetically for each type of farmers (Table 1).

- ◆ The lack of fodder in winter is said to be a major constraint for most of the respondents. It has negative effect on performances, reproduction and resistance to diseases. Last year (2000) there was an epidemic (*tu huyet trung*) that led to the death of many buffaloes.
- ◆ Apart from individual activities, the project may assist the village in a collective activity proposed by one farmer: grow mucuna on the collective pasture area to regenerate the soil and overgrow the weed. Mucuna is easily cleared and it is possible to grow other crops after that. This project could thus initiate a collective management dynamic partly overcoming the individual implementation constraints.
- ◆ Many respondents worry about the fact that the fodder crops planting time (next March) may coincide with spring season. There will be a shortage of labor force during this time and some may not be able to implement these innovations.
- ◆ Very few of the surveyed farmers were interested in rotation between forage and food crops. It seems that it is considered as a waste of land and the farmers prefer to associate these crops, which highlights the land saturation situation.
- ◆ Some farmers think that the urea treated straw, especially from maize, can be dangerous for the livestock.
- ◆ Only a few persons are interested in growing winter oats because the paddy fields are usually not fenced. This absence of fencing is also a constraint for innovation implementation in the upland crop area, as most of the crop associations are planted in the residential/garden/upland crop area where fencing is easier (slope and fencing material available in situ).

As explained before, the chosen participants represent of diversified situations. This diversity is first expressed through the farmers' agricultural and animal resources (Table 2).

[2] We consider the social system analyze (structure and interactions) as very important because the innovation diffusion is processed though local networks that influence the access to strategic information.

Table 1: Synthetized information from farmer interviews (survey data). The general columns describe ideas for which there was a consensus in the community. The specific columns are based on individual comments made by farmers in the indicated categories.

Type/ husbandry	Comments		Plans		Constraints	
	general	*specific*	*general*	*specific*	*general*	*specific*
No buffaloes	presentation useful for: - knowing history; - long-term strategy building; - understanding the limits of natural forage resources; - knowledge of constraints and their resolution	Interested by the double function of cover crops: feeding + soil restoration	● gradual innovation implementation (stepwise) ● using cover crops also for fish and pig feeding	animals sold, sometimes replaced by a cultivator but plan to buy 1-2 buffaloes	● lack of fodder, especially in winter ● weed control ● fences (cost and efficiency) ● human labor force ● inputs and knowledge: need for material and technical assistance	● animal mortality ● animal labor force
Buffaloes for labor		expecting individual allocations from collective area		cowshed near the upland fields		● under-exploited land ● time for grass cutting
Capitalization (buff. and/or ox)		cover crop = complementary fodder		storage for treated straw		● livestock roaming ● plot scattering and distance; slope
Diversification (buff., ox, goat)		unwilling to exploit forest (labor cost and conservation)		● mucuna in the collective area ● collective organization		● lack of agricultural resources ● animal watching

Table 2: Basic statistics about some farmers' agricultural and animal resources (source: SAM database)

Parameter	no. workers / household	paddy area (ha)	upland area (ha)	forestland area (ha)	no. buffalo	no. cattle
mean	2.9	3186	2918	8081	3.8	0.7
max.	10	6750	10 000	20 000	15	8
min.	1.5	590	0	1500	0	0

Given that the strategies result from the interaction between what farmers resources, capabilities and objectives, the diversity of resources corresponds to a diversity of reactions and innovation choices.

The animal husbandry objectives differ according to circumstances. It can just consist in owning a couple of buffaloes for labor requirement, having a living capital, produce meat or developing diversified husbandry activities.

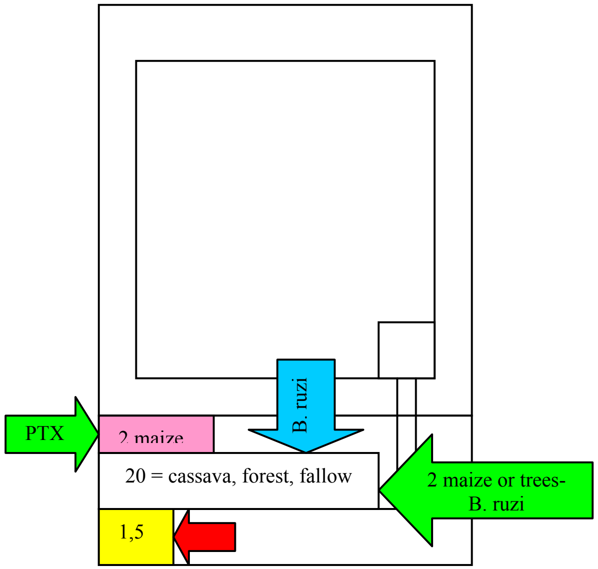
All of these positions condition the interest of the farmers, their involvement in the simulation, their choice of innovations and moreover their will to actually implement these innovations. For instance, farmers who owned no large ruminants played the game regardless, either because they plan to buy an animal or are interested by the soil fertility improvement function of the techniques, or the feeding value of the cover plants for fish farming.

We can also see that some constraints play on the whole community while other are situation-specific: for some farmers, it is limited labor force while for others it is the scattering of their plots, the difficulty of making their buffaloes and/or cattle survive the winter or of fencing their plots.

Focus on 3 contrasted individual models

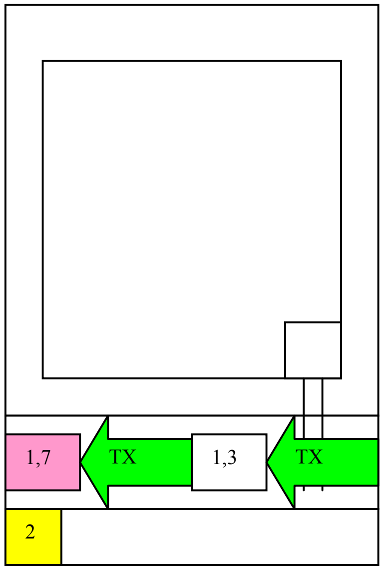
Surfaces are expressed in local units (1 *bung* = 1000 m^2)

Case n°1: buffaloes for labor
(57% farmers; 1-3 heads)



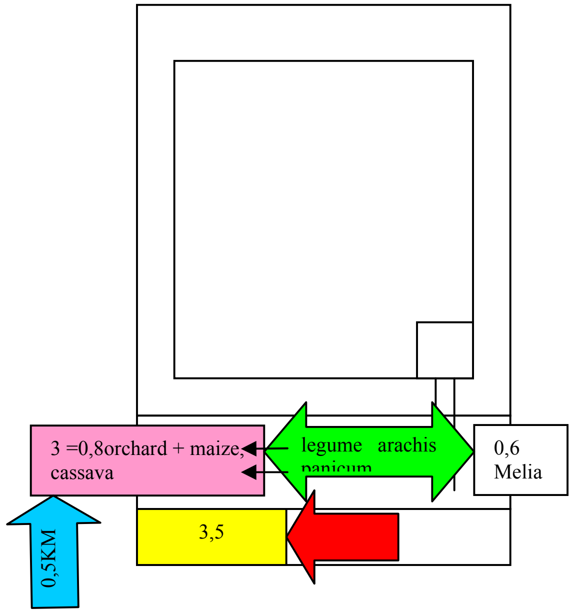
The farmer (woman) who filled this model is already involved in the project experiments with fodder-cover plants. Because of limited paddy resources, she focuses on extra-agricultural activities, and does not fully exploit the huge attributed upland area. In this situation, the development of the buffalo herd would also be a source of income. Given the lack of labor force, her strategy is to progressively fence and settle fodder-cover plants in the forested area, in the perspective of extensive husbandry. Grazing in this area would limit labor requirements and ensure a sufficient feeding in winter, which is perceived as a crisis period for fodder.

Case n°2: no buffalo
(21% farmers)



This farmer sold his buffaloes to buy a cultivator. Even if he is engaged in a mechanization process, he plans to always have a couple of animals on his farm. Given his limited agricultural resources, his strategy is to intensify crop production. In this perspective, owning two sources of soil tillage would ensure him the sufficient labor force for paddy cultivation (plowing/harrowing).

Case n°3: capitalization
(22% farmers ; 4-15 heads)



This farmer has a large number of resources and carefully monitors his farming system. He has a precise idea about which innovation to implement with which crop. He is also interested by the possibility of feeding fishes with cover crops. The scattering of his plots constitutes his main constraint. He is also concerned about the duration of fences from one season to the next. This would be a good candidate to test living fences.

5.2 Innovation implementation

For entering the winter season, two innovations were proposed for diffusion: urea treated rice straw and winter oats. Even if not direct applications from conservation agriculture principles, these innovations are strategic because, as presented before, winter remains a crisis period for animal feeding and these innovations are part of a potential annual feeding system based on CSC techniques to be further introduced. The aim of these two components of the feeding systems is to lighten animal pressure on natural meadow and forest resources in the winter season. Moreover, as mentioned below, they could be further implemented in a conservation agriculture perspective.

<u>Urea treated rice straw</u>

Given farmers' reluctance to treat maize straw (represented as not suited for ruminant feeding), we propose the urea treatment of rice straw, which confers three advantages:

① Better conservation conditions: untreated straw stock is sometimes damaged by fungi, rats and insects;

② Increased digestibility: the treatment can be seen as a "pre-digestion" which enables the animal to eat higher quantity;

③ Increased fodder value.

Usually, farmers burn the rice straw from irrigated fields after the autumn harvest and keep a small part which is dried and used as punctual fodder supply during the winter. Although the ash is then used to fertilize rice nurseries, the net result is the exporting of plant material from the field. Exporting rice straw for animals and then providing a manure source for lowland rice fields seems to us to be a more balanced management.

Briefly, the technique consists of cutting dry rice straw into segments (between 15-25 cm), which are watered with a 4% urea water solution (between 80-100% DM) and then salted (0.5-1% DM). Two options are chosen for anaerobic fermentation: hole or nylon bags. Fermentation duration recommendations range from 3 to 4 weeks.

This technique has been introduced through 3 steps:

❶ Preliminary discussions with the farmers who chose this innovation during the simulation (12 in total), about their objectives, constraints, techniques, and treatment demonstration[3];

❷ Development discussions, identification of farmers ready to treat their own straw and demonstration of the treated straw distribution to the buffaloes owned by the project;

❸ Farmers' straw treatment (invitation of the local technical extension service members) and distribution of technical form;

Finally, 6 farmers did not implement this technique because of insufficient stock, lack of labor (for cutting straw and digging holes) or because they wanted to check the results of this technique with their neighbors. We nonetheless assisted 6 farmers (50% implementation ratio) with straw treatment, who found the technique simple, cheap and not overly labor consuming. They all chose the nylon bag method of fermentation because they found it better in terms of conservation and distribution or because their stock was not large enough to justify digging a hole. The treated quantity was 50 kg (gross weight), except for one case of 100 kg. The treatment was planned according to the distribution time request, corresponding to the Vietnamese New Year week (*Têt*), which is a complete resting time and to the weeks following *Têt* when buffaloes have to plough. Some of them plan to treat the rest of their stock before the end of the winter and/or to increase the treated stock next winter.

<u>Winter oats</u>

Most of the farmers do not use their irrigated ricefields during the winter (though a few grow vegetables or late maize). They usually plough and then flood their field in December-January (depending on their labor availability) in order to keep it ready from the beginning of the rainy season for the first cycle of rice. Our proposition was that they

[3] We also took the opportunity of this demonstration to experiment different options, in order to propose personalized modalities to the farmers: hole/bag fermentation, non cut straw, non salted straw, fermentation time ranging from 3 to 8 weeks.

grow oats in these fields as a winter crop in order to have green fodder during the winter.

The idea is to model a field surface and a daily cutting plot, enabling the continuous cutting of oats during the winter (such that the first plots have sufficient regrowth when the last plots are cut), in function of the number of animals to be fed, required quantity per animal and oat re-growth speed under the local conditions.

If the farmers do not have the required field surface, a combination oat-natural vegetation-dry/treated rice straw could be determined with them in order to improve winter feeding.

During the simulation, only 2 farmers chose this innovation both because of the fencing constraint (in winter, animals are roaming in the irrigated ricefields to benefit from the low plant re-growth until the winter plowing and flooding) and because of the novelty of this crop. Finally, the project provided material help for fencing and oat was sowed directly under the rice straw mulch.

In this case, we are not strictly in a CSC system because plots will be ploughed and flooded for next rice season. Because of the specificity of lowland rice cropping (quasi-permanent "water cover"), we chose not to develop CSC techniques, which are more specifically suited to upland cropping in our situation. However, this crop could be further managed through other options:

- growing oats in waterable gardens without tillage, rotated with vegetables;
- exporting oat biomass as mulch for other fields (holistic farming system prespective) and as animal fodder with manure restitution to the source field;
- CSC rainfed rice-oat rotation in poorly irrigated lowland fields.

6 Conclusions

Farmers' reactions and interest for the participatory simulation are very encouraging. They provided many new elements of diagnostic and helped us to improve the proposed model. They were clearly interested by the proposed innovations and asked very relevant questions. We could verify during the follow-up visits that farmers were unquestionably sensitized to local issues related to crop-livestock interactions and were ready to take concrete action as they did during the simulation. However, most of them are still reluctant to develop concerted or community-based livestock management rules. Although they were conscious of the benefits for the whole village, the diffusion process has to go through the first stage of individual adoption, taking into account the particular circumstances of each household. Our participatory simulation method proved very effective in supporting individual decision-making.

After this first test in real conditions the method will be applied to other villages in Bac Kan province. We need to test it in many different natural and human environments for further validation. Then it can be generalized and applied on a routine basis by local extension agents.

Concerning the designing of feeding systems, important work is still to be done, such as adapting to situation-specific constraints and labor allocation and to enable farmers to concretely implement the innovations (seeds, environment-friendly herbicides, fences,...). In this perspective, socio-economic components have to be closely considered, as far as social networks, policies and possibly credit are concerned. The feedback received from farmers during the participatory simulations will also help to improve the technical innovations along those lines.

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