Improving Smallholder Livelihood and Soil Management in Laos through Conservation Agriculture and DMC systems

Lienhard, P., Tran Quoc, H., Khamxaykhay, C., Sosomphou, T., Tivet, F., Lestrelin, G., Panyasiri, K., and Séguy, L.
• **Cases of Southern Xayabury and Xieng Khouang Province**
  – Why do we have to manage our soils differently?
• **About the Lao National Agro-Ecology Programme**
• **What is Conservation Agriculture & Direct Seeding Mulch Based Cropping Systems**
• **Examples:**
  – Implementation of DMC systems with small hold farms in Southern Xayabury
  – Regeneration of savannah grasslands in the vicinity of Phonsavanh
• **Challenges in scaling-up DMC systems**
Characteristics of Southern Xayabury and Xieng Khouang Province
In Southern Xayabury (Mekong corridor) where market forces are prevalent, shifting cultivation systems have given way to more conventional high input agricultural systems.

- High environmental and financial costs of the present agriculture production.
- Increasing use of pesticides is another major issue from this agricultural intensification. Herbicides are now widely used for land preparation after burning or ploughing, and for post-emergence application on maize.
Environmental, Social and economic costs

- Within a few years, this conventional land preparation generates heavy soil degradation, risks of pollution by misuse of pesticides and depletion of natural resources.
- Destruction of infrastructures: paddy fields, roads.
- Seasonal migration occurs due to collapsing livelihoods.
In Xieng Khouang Province, it is estimated that more than 60,000 ha of land (ecology of Plain of Jars) are ‘under-utilized’ by smallholders.
In remote areas, the traditional swidden system, with long rotations, has been put under pressure due to modification of land access and increasing population pressure.
Why do we have to manage our soils differently?
• The soil is the base of the agro systems. It is not a renewable resource but a living system which can be irreversibly affected by unsuitable human interventions.

• Maintaining and enhancing productive capacity of the soil and preservation of natural resources is a crucial element for long-term improvement of smallholders’ conditions and poverty alleviation (GoL, 2004).
Rationale management of the soil has to reach 4 main objectives

- Contributing to self-sufficiency producing food for communities
- Producing agricultural products (for market) with minimum use of inputs
- Preserving soil potentialities
- Minimizing the effects on environment
Promotion of Conservation Agriculture (CA) and DMC systems in Laos
About the Lao National Agro-Ecology Programme

- PRONAE is a partnership between NAFRI and CIRAD.
- It is funded by the French Government through the French Agency for Development (AFD), the French Global Environment Facility (FFEM) and the Ministry of Foreign Affairs.
About the Lao National Agro-Ecology Programme

PRONAE is a partnership between NAFRI and CIRAD

Three mains locations
- 6 districts covering 12,000 km²
- Headquarter in Vientiane

Staff
- 44 permanent staff
- 33 agronomists - extensionists. 52% come from extension agencies at local level (PAFO-DAFO) and MAF
Institutional framework

- Agreement PRONAE – Provincial Agriculture and Forestry Office of Xayabury and Xieng Khouang Provinces

- Specific Agreement (2005-2008) with a Rural Development Project of Xayabury Province (PASS-PCADR)

- Contract for Consultancy services for NAFES and Nam Ngum River Basin Development Project
  - Feasibility study to implement Conservation Agriculture in Nam Ngum River basin
  - Training of DAFEO staff on integrated approach and Conservation Agriculture
  - Demonstrations fields

Decentralization of research activities and permanent transfer from research to extension
Methodological framework
Approach characterized by 5 components

- **Initial assessment**: Technical, economic and social assessment of farming systems, physical and human environments

- **Reference data acquisition**: Long-term implementation to adapt systems to local conditions and to generate a large range of technologies. Characterization for short, medium and long-term biological and physicochemical processes.

- **Adaptation and validation with smallholders**: On-farm implementation with farmers groups. At landscape and village level: analyses of the conditions for adoption.

- **Training and Information**: Permanent training of smallholders, extension agents and researchers. Information for policy-makers and stakeholders.

- **Monitoring and Evaluation**: Feed-back agriculture – development - research. Dissemination process, transfer of information between stakeholders.
Main Research and Development goals

- Validation with smallholders of Direct Seeding Mulch-Based Cropping (DMC) systems for the Mekong Corridor
- Regeneration of altitude plains (Plain of Jars, Xieng Khouang Province)
- Diversification and Stabilization of swidden systems
- Diversification and integration between cropping (annual and perennial) and livestock production
- Alternative DMC systems for the upper terraces on lowland
Research topics

Reference data acquisition

- Long-term implementation to adapt systems to local conditions and to generate a large range of technologies
- Characterization for short, medium and ‘long-term’ biological and physicochemical processes:
  - Productivity (grain, straw, roots)
  - Chemical, physical and biological soil (Kasetsart University, Federal University of Ponta Grossa - Parana) characteristics
  - Changes in flora (EU-OSWALD)
  - Externalities: soil, water and nutrients losses, xenobiotics pollution
Policy support

- Decree of the Ministerial Council (April 2005) and of the Ministry of Agriculture and Forestry (May 2005) to promote Conservation Agriculture and Direct Seeding Mulch-Based Cropping Systems in Laos.
What is Conservation Agriculture?

- Permanent soil cover
- No soil disturbance
- Diversified crop rotations
Residue retention distinguishes Conservation Agriculture from conventional farming systems, which are characterized by leaving the soil bare and unprotected, exposed to climatic agents.

The soil cover is not incorporated into the soil by tillage.

FAO, 2002
The main principle is that the soil is no longer disturbed by mechanical action (ploughing, hoeing...) and always kept covered by crop residues and cover crop
Principles & Functions

- Mechanical action on soil are performed only for sowing by the use of specific equipments (sowing machine with cutting disks)
Mechanical actions (hoeing, ploughing) are replaced by biological improvement of soil structure by rooting systems of relay crops.
Spatial and temporal diversified schemes (rotations, association, annual crop sequence) are provided in order to increase farming incomes by reducing cost production and climatic risks.
Principles & Functions

- Nutritional function for livestock by rational use of fodder
Principles & Functions

- Nutritional function for the main crop via mulch mineralization
Principles & Functions

- Integrated management of weeds through shade and/or allelopathic effects
Recycling nutrients and water leached deep into the soil below soil layers used by cash crops or rice by deep rooting systems of the cover crops
Principles & Functions

- An organic skeleton to maintain the soil constituted by the rooting systems and by biological activity.

One of the main functions of cover crops is to enhance belowground insect and microbial activity which improve soil structure and plant nutrition.
On-farm experiments

Implementation of DMC systems with smallhold farms in Southern Xayabury (Mekong corridor)
Crop residue management can be a first step towards reducing losses of soil and mineral elements, as well as a way of saving money, increasing net income and labour productivity.
Validation of alternatives cropping systems based on direct seeding on crop residues

<table>
<thead>
<tr>
<th>Villages and farmers</th>
<th>Land preparation</th>
<th>Production cost ($US/ha)</th>
<th>Labour (md/ha)</th>
<th>Yield (Kg/ha) 2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>Net income ($US/ha)</th>
<th>Labour productivity ($US/day)</th>
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<tbody>
<tr>
<td>Houay Lod (6)</td>
<td>Ploughing</td>
<td>226</td>
<td>51</td>
<td>4726</td>
<td>95</td>
<td>56</td>
<td>308</td>
<td>429</td>
<td>7.67</td>
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<tr>
<td></td>
<td>DMC</td>
<td>95</td>
<td>56</td>
<td>4976</td>
<td>95</td>
<td>56</td>
<td>384</td>
<td>429</td>
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<tr>
<td>Kengsao (5)</td>
<td>Ploughing</td>
<td>201</td>
<td>94</td>
<td>4332</td>
<td>5215</td>
<td>5190</td>
<td>3659</td>
<td>234</td>
<td>3.25</td>
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<tr>
<td></td>
<td>DMC</td>
<td>90</td>
<td>60</td>
<td>5481</td>
<td>4583</td>
<td>6355</td>
<td>4036</td>
<td>423</td>
<td>7.10</td>
</tr>
<tr>
<td>Paktom (11)</td>
<td>Ploughing</td>
<td>135</td>
<td>35</td>
<td>2787</td>
<td>3477</td>
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<td>2786</td>
<td>146</td>
<td>3.90</td>
</tr>
<tr>
<td></td>
<td>DMC</td>
<td>95</td>
<td>40</td>
<td>2563</td>
<td>3383</td>
<td>3150</td>
<td>2676</td>
<td>161</td>
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<tr>
<td>Bouamlao (4)</td>
<td>Ploughing</td>
<td>159</td>
<td>50</td>
<td>5073</td>
<td>4629</td>
<td>5330</td>
<td>306</td>
<td>5.80</td>
<td>85.60</td>
</tr>
<tr>
<td></td>
<td>DMC</td>
<td>77</td>
<td>51</td>
<td>5044</td>
<td>3727</td>
<td>5220</td>
<td>3742</td>
<td>7.80</td>
<td>85.60</td>
</tr>
</tbody>
</table>

Labour (md/ha) Paktom (11) Bouamlao (4)
**Dissemination of DMC systems according to surface (%) and smallholders (%) between 2003 and 2006 in 4 villages**

<table>
<thead>
<tr>
<th>Villages</th>
<th>Houay Lod</th>
<th>Paktom (North)</th>
<th>Nongpakbong</th>
<th>Bouamlao</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>[90 - 103]</td>
<td>[90 - 124]</td>
<td>[74 - 80]</td>
</tr>
<tr>
<td>Slash and burn</td>
<td>72,2 54,5 17,6 18,5</td>
<td>16,6 13,7 6,8 13,4</td>
<td>35,1 33,3 38,1 40,9</td>
<td>7,6 2,5 0,1 1,7</td>
</tr>
<tr>
<td>Ploughing</td>
<td>22 23,4 38,5 38,8</td>
<td>80,1 81,9 84 71,7</td>
<td>58,3 56,9 43,1 17,1</td>
<td>92,4 97,5 99,9 90,1</td>
</tr>
<tr>
<td>DMC</td>
<td>5,8 22,1 43,9 42,7</td>
<td>3,3 4,4 9,2 14,9</td>
<td>6,6 9,8 18,8 42,0</td>
<td>0 0 0 8,2</td>
</tr>
</tbody>
</table>

**Villages**

<table>
<thead>
<tr>
<th>Houay Lod</th>
<th>Paktom (North)</th>
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<tbody>
<tr>
<td>169</td>
<td>131</td>
<td>101</td>
<td>383</td>
</tr>
<tr>
<td>[90 - 103]</td>
<td>[90 - 124]</td>
<td>[74 - 80]</td>
<td>[155 - 137]</td>
</tr>
<tr>
<td>% of Smallholders</td>
<td>4 50 66</td>
<td>8 50 68</td>
<td>5 22 76</td>
</tr>
</tbody>
</table>
Dissemination of DMC systems according to surface and smallholders in 2006 in 5 villages.

<table>
<thead>
<tr>
<th></th>
<th>PRONAE Smallholders</th>
<th>PRONAE Area (ha)</th>
<th>PASS Smallholders</th>
<th>PASS Area (ha)</th>
<th>Spontaneous dissemination Smallholders</th>
<th>Spontaneous dissemination Area (ha)</th>
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<tr>
<td>Bouamlao</td>
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<td>15</td>
<td>9</td>
<td>17</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Kengsao</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Houaylod</td>
<td>7</td>
<td>18</td>
<td>49</td>
<td>82</td>
<td>37</td>
<td>-</td>
</tr>
<tr>
<td>Paktom</td>
<td>21</td>
<td>15</td>
<td>15</td>
<td>24</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>Nongpakbong</td>
<td>7</td>
<td>7</td>
<td>57</td>
<td>48</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>52</strong></td>
<td><strong>65</strong></td>
<td><strong>130</strong></td>
<td><strong>171</strong></td>
<td><strong>69</strong></td>
<td><strong>-</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Smallholder</th>
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<tbody>
<tr>
<td>Bouamlao</td>
<td>16</td>
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<td>10</td>
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<td>Houaylod</td>
<td>93</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>Paktom</td>
<td>58</td>
<td>&gt; 39</td>
</tr>
<tr>
<td>Nongpakbong</td>
<td>74</td>
<td>&gt; 55</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>251</strong></td>
<td><strong>&gt; 236</strong></td>
</tr>
</tbody>
</table>

In 2006, a development project (PASS-PCADR) extended no-till systems in 20 villages (385 families and 400 ha)
Disadvantages of DMC systems for maize monocropping

Residues management:
- Increasing weed populations
- Low soil improvement (OM)
Biophysical advantages of No-till systems with residues management

Under no-till systems:
- Increase of aggregate size, decreasing soil erodibility
- Decrease of bulk density
- Increase of soil permeability
Needs for more efficient DMC systems

Despite rapid adoption in some areas, no-tillage systems have to be improved with rational crop rotations, relay crops and cover crops in order to diversify the production, and so reduce agronomic, economic and climatic risks while optimising the main functions of DMC systems through adequate use of main and relay crops.

Year 1: Maize + *B. ruziziensis*

Year 2: Rice-bean

Or

Soybean / Finger millet
Savannah grasslands on altitude plains
Regeneration of savannah grasslands on altitude plains

A large range of forage species (Brachiaria sp., Stylosanthes, Cajanus cajan, Eleusine coracana) and cover crops (Crotalaria sp.), tolerant to drought and soil acidity, is being used to regenerate waste lands.

First step: Livestock production

Second step: Annual cropping and diversification (trees)
Cattle fattening on *B. ruziziensis* pasture during the rainy season

In 2006, mean growth rate from end of May to end of October reached 539 g/day with no protein supplement.

On natural pasture land: 100 – 170 g/day.
The first year fencing and fertiliser formed the main expenses. Cost of fencing could be reduced using local materials and by growing living fences.

In 2006, without taking into account seed production, bulls fattening represents an income per ha of $362 (1.8 t/ha of paddy) and a labour productivity of 6.6 $US/day.
Regeneration of savannah grasslands on altitude plains
(upper part of Nam Ngum River Basin)

Traditional management of savannah grasslands

Great social and environmental impacts: land ‘allocation’ and land protection during the dry season
Possibility of reafforestation, diversification and new income generation (livestock, forage seed production)

Wildfires on the Plain of Jars, November 2006
Regeneration of savannah grasslands on higher plains

A large range of forage species (Brachiaria sp., Stylosanthes, Cajanus cajan, Eleusine coracana) and cover crops (Crotalaria sp.), tolerant to drought and soil acidity, is being used to regenerate waste lands.

- Rotational sequences between improved pasture and edible or cash crops (rice, maize, soybean) direct-seeded onto forage mulch are tested.
Regeneration of savannah grasslands on higher plains

- Rice direct seeded on Brachiaria ruziziensis mulch, Plain of Jars, June 2006
Annual cropping on the Plain of Jars

<table>
<thead>
<tr>
<th>System</th>
<th>Rice after two years of <em>B. ruziziensis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no fodder exportation</td>
</tr>
<tr>
<td>Sowing</td>
<td>1/6</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>30N - 45 P₂O₅ - 30K₂O</td>
</tr>
<tr>
<td>Yield (kg/ha)</td>
<td>1744 ± 224</td>
</tr>
<tr>
<td>Gross income ($US/ha)</td>
<td>401 ± 52</td>
</tr>
<tr>
<td>Production cost ($US/ha)</td>
<td>157</td>
</tr>
<tr>
<td>Income ($US/ha)</td>
<td>248 ± 52</td>
</tr>
<tr>
<td>Labour inputs</td>
<td>0</td>
</tr>
<tr>
<td>Labour productivity ($US/day)</td>
<td>5.2 ± 1.1</td>
</tr>
</tbody>
</table>

Characterization of biological and physicochemical processes for different systems
Annual cropping on the Plain of Jars

May to beginning of August
Finger millet

August to...
Finger millet + pigeon pea

May to ...
Rice + Crotalaria / S. guianensis

Radish, oat, bean, wheat...
A global approach involving credit access, technical and political support has to be defined to develop productive and efficient systems (annual and perennial cropping, livestock) on this ecology. This poses a great challenge which, if grasped, could yield great benefits on the upper part of the Nam Ngum river basin.
Challenges in scaling-up this approach and DMC systems
Challenges in scaling-up this approach and DMC systems

Positive results from DMC are evident; however, different constraints limit the dissemination of these systems even if agronomic and economic successes have been highlighted.

- Economic incentives have to be promoted. One of the major limiting factors to adoption may be that the practice promoted was first perceived as being closely associated with a need to use cash income for equipment and inputs.

- Labour force is one of the main limiting factors, and specific tools have to be promote in order to reduce drudgery and labour inputs.

- Rules must be defined at the community level for management of residues and cover crops during the dry season.
Challenges in scaling-up this approach and DMC systems

- Land allocation must be flexible, taking into account the diversity of livelihoods in the uplands.
- Market access for forage seed and relay crops (*Brachiaria* sp., *S. guianensis*, finger millet, pigeon pea, *Sorghum*, pearl millet…) have to be found.
- Organic systems should be integrated into DMC systems in order to ensure sustainable and environmentally-friendly agriculture.
- Structuring the relationship between smallholders – extension agents and private sector.
- Methods/Terms of transfer of this approach and systems to smallholders, extension agents, private sector and policy-makers.
Continuous and full soil cover is the key factor for successful CA & DMC systems.

Thank You for your attention.
Altieri (2002) and Dalgaard et al. (2003) define agro-ecology as a holistic study that focuses on the form, dynamics and functions of agroecosystems, including all physical, economical and human environments.

Direct seeding mulch-based cropping systems are considered as one component of agro-ecology strategy.