Working Towards Sustainable Land Management (SLM)

A collection of SLM Technologies from Cambodia

2018

IFAD
Investing in rural people

WOCAT
World Overview of Conservation Approaches and Technologies

UNIVERSITÄT BERN
CDE CENTRE FOR DEVELOPMENT AND ENVIRONMENT

Scaling-up Sustainable Land Management Practices by Smallholder Farmers

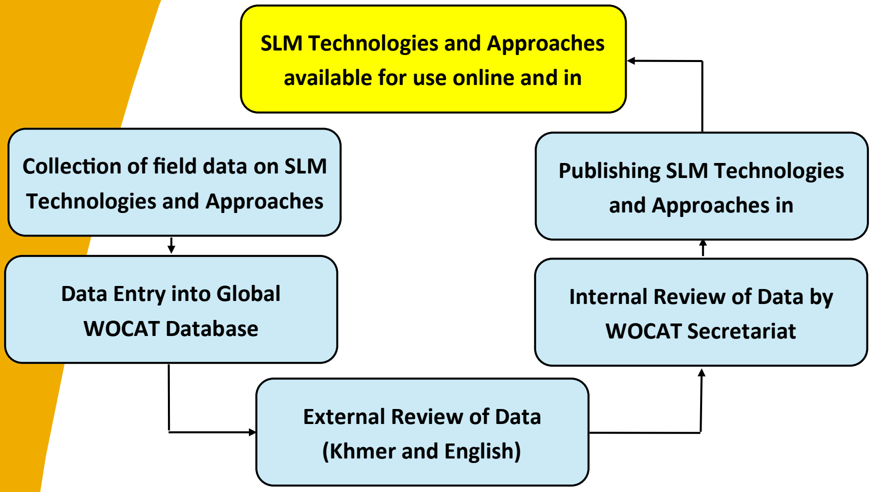
Background: This collection of SLM Technologies and Approaches was compiled as part of the project 'Scaling-up SLM practices by smallholder farmers' funded by the International Fund for Agriculture Development (IFAD).

Capacity building: Before SLM Technologies and Approaches were documented, a Training of Trainers (ToT) was carried out at national level with staff and officials from RUA, MAFF and GDA. Then, further trainings of extension officials were implemented at provincial and district level of 5 provinces. SLM Technologies and Approaches were then documented by RUA together with extension staff, using the standardized WOCAT tools.

SLM Technologies belonging to the following five categories are included in this collection:

Agro-forestry, Cropping management, Home garden and integrated farming system, Manuring and composting and Water harvesting and water management.

SLM Technologies and Approaches Documentation Process:



Collection of field data on SLM Technologies and Approaches

Data Entry into Global WOCAT Database

External Review of Data (Khmer and English)

Internal Review of Data by WOCAT Secretariat

Publishing SLM Technologies and Approaches in

SLM Technologies and Approaches available for use online and in

Target groups: This collection of SLM Technologies and Approaches available both in Khmer and English language serves as a tool for technical staff, extension workers, project implementers, SLM planners, farmers and policy makers. It includes the most relevant information on different SLM practices including details on their implementation, costs, ecological and socio-economic benefits and disadvantages etc. to support knowledge-based decision-making in SLM.

Acknowledgement: Thanks to the agricultural officials from the Provincial Department of Agriculture, Forestry and Fisheries at the target provinces (Kampong Chhnang, Pursat, Battambang, Preah Vihear and Kratie) for supporting the data collection process. Also, special thanks to farmers for providing information and knowledge-based experiences as well as to extension workers and field technical staff for their assistance in data collection.

Implementing institutions: WOCAT Secretariat hosted by the Centre for Development and Environment (CDE) of the University of Bern, Switzerland, in collaboration with Center for Agricultural and Environmental Studies (CAES), the Royal University of Agriculture (RUA), Cambodia.

Project duration: February 2016 – March 2019

For further information on

WOCAT SLM Database,

please visit www.wocat.net

WOCAT SLM Database in Khmer

Version, Please visit

https://qcat.wocat.net/km/wocat/

SLM Technologies and Approaches, Please visit

https://qcat.wocat.net/en/wocat/list

What is Sustainable Land Management (SLM)?

The use of land resources – including soils, water, vegetation, and animals to produce goods and provide services to meet changing human needs.

SLM Technology: *A physical practice on the land that controls land degradation, enhances productivity, and/ or other ecosystem services. A Technology consists of one or several measures, such as agronomic, vegetative, structural, and management measures.*

SLM Approach: *The ways and means used to implement one or several SLM Technologies.*

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A. Agroforestry


Growing eggplant as inter crop with mango trees and use rice straw as soil cover (Soben Kim)

Intercropping of eggplants between mango trees using rice straw mulching to reduce evaporation (Cambodia)

Growing eggplant under mango trees

DESCRIPTION

Intercropping of eggplants between mango trees and the application of straw mulching on the plants' roots and the land so as to retain soil moisture by reducing heat-induced evaporation. When the rice straw rots, it provides organic matter and makes soil less compact. The farmer can benefit from the short-term crop for a period of three years before the mango trees fully produce fruits.

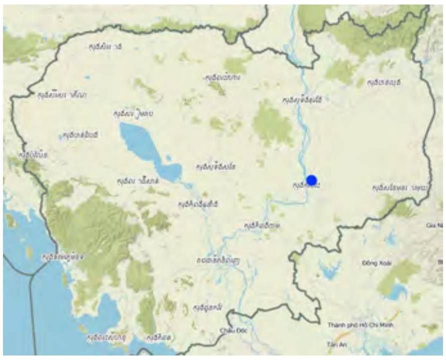
Intercropping of a short term crop between the fruit trees which are the long term crop (mango trees which will provide fruit in their third year depending on the species variety and maintenance) is a best agroforestry practice which provides both economic and environmental benefits. When the mango trees are still young and have not yet produced fruit, there is also free space between the trees. In order to gain additional benefits and to avoid weeds growing that could be harmful to the mango trees, the growing of eggplants with rice straw mulching could provide co-benefits in the form of maintaining, weed control, watering, and the application of fertilizer for the mango trees. The eggplants could produce fruit within three months after having been planted and they can be harvested for several months in a year. In this way farmers can generate income for their daily expenditure before the mango trees produce fruit. By using this technology, farmers are able to improve their livelihoods compared with before.

In this SLM technology, the mango trees, eggplants and mulched rice straw interact beneficially. In the dry season, the trees provide some shade for the eggplants and the rice straw on the eggplants' roots and land helps retain soil moisture reducing evaporation, and this prevents the crops from withering during hot days. In addition, when the farmer waters the eggplant,it also provides water to the trees. In rainy season, the rice straw and the eggplants act as an important vegetation cover for the prevention of soil erosion through surface run-off during heavy rainfall. Besides the rice straw and its decayed materials are a crucial food source for micro-organisms in the soil that improve the cycling of nutrients and the soil less compact, enabling a better growth of the crops.

In this technology, the mango trees are planted in row with an interval of six metres and the eggplants are transplanted among the rows of trees ensuring that there is a distance of one metre between each plant within a row, and a distance of 1.5 metres between one row and another. The pit for each mango tree is 70x70x70cm and a mixture of burned rice husk, cow manure and woody herb is added as fertilizer in the bottom of the pit. When planting, the compost or slurry from the of the bio-digester is also mixed in with the soil. Eggplant seedlings are transplanted in 10-cm holes using 20-30 day-old seedlings. Then the farmer applied rice straw mulching on the roots of eggplant and mango trees' roots and applied on the free space of the land. The transplanted eggplants are watered on a daily basis, while the watering of the mango trees is carried out twice per week.
Weeding is done regularly so that the weeds do not absorb too many nutrients from the soil even there is no much weed. The farmer applies compost twice a year, usually once at the beginning of the rainy season in May, and also in October.

When the eggplants start to produce fruit, it takes around one hour for the farmer to

LOCATION



Location: Field, Kamboa village, Kou Loab commune, Chetr Borei district, Kratie, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites
- 106.08695, 12.54908

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 2012

Type of introduction
- ☐ through land users' innovation
- ☐ as part of a traditional system (> 50 years)
- ☐ during experiments/ research
- ☑ through projects/ external interventions

harvest the crop on a daily basis. Weeding is sometimes carried out during the harvest. It is suggested that one should consider a rotation of short-term crops in order to maximize the benefits of this SLM technology, because growing one type of crop could absorb exact the same nutrients from the soil so the second crop growing are not very good and could cause disease outbreak on the crop. The rotation of crops in this case could include eggplants, mung beans, sweet corn or cucumbers. However it should examining the market demands as well.


Farmer applying compost on the eggplant (Sophea Tim)


Rice straw mulching helps keep soil moisture (Sophea Tim)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose
☑ improve production
☑ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact
☑ Obtaining economic benefits from the short-term crops while the mango is not ready to produce fruits, and the rice straw helps reduce evaporation maintaining soil moisture.

Land use

Mixed (crops/ grazing/ trees), incl. agroforestry - Agroforestry
Main products/ services: Mango and eggplant

Water supply
☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 1

Land use before implementation of the Technology: Degraded forest

Livestock density: 19 cows and the manure is used in biodigester production and slurry from biodigester is used for cultivation crops. Those number of cows are enought for biodigester production everyday.

Purpose related to land degradation
☐ prevent land degradation
☑ reduce land degradation
☑ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion

physical soil deterioration - Pc: compaction, Pu: loss of bio-productive function due to other activities

biological degradation - Bc: reduction of vegetation cover, Bl: loss of soil life, Bp: increase of pests/ diseases loss of predators

water degradation - Ha: aridification

SLM group
- agroforestry
- improved ground/ vegetation cover
- integrated soil fertility management

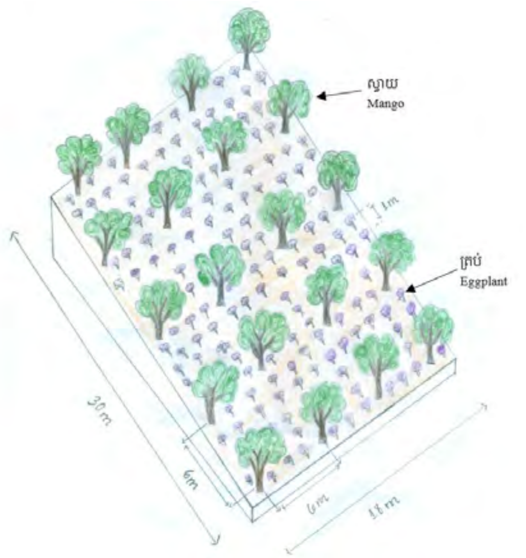
SLM measures

agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility, A3: Soil surface treatment

vegetative measures - V1: Tree and shrub cover, V2: Grasses and perennial herbaceous plants

TECHNICAL DRAWING

Technical specifications
The technology contains the 25 total planted mango trees and 350 eggplants. The area of applying this technology is 540square meters(width 18 meters and length 30 meters).



Author: Vanny Om and Sophea Tim

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **540 square meter**)
- Currency used for cost calculation: **Khmer Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Khmer Riel
- Average wage cost of hired labour per day: 30,000 Riel

Most important factors affecting the costs
The cost of water pumping machine is high, cost of mango trees and eggplant seeds, cost of hiring labor to plough the soil. But she doesn't expend on buying fertilizer because she use her own cow manure.

Establishment activities

1. Ploughing the soil to sun dry (Timing/ frequency: May)
2. Digging the pits for mango trees (Timing/ frequency: May)
3. Applying the mixture of cow manure, burned rice hush and woody herb in the pits (Timing/ frequency: May)
4. Planting the mango trees (Timing/ frequency: May)
5. Applying slurry from biodigester on the plant roots. (Timing/ frequency: June)
6. Prepare the soil mixing with cow manure, apply lime to grow the crops. (Timing/ frequency: June)
7. Digging holes and transplant eggplant (Timing/ frequency: June)
8. Spreading the rice straw (Timing/ frequency: June)

Establishment inputs and costs (per 540 square meter)

Specify input	Unit	Quantity	Costs per Unit (Khmer Riel)	Total costs per input (Khmer Riel)	% of costs borne by land users
Labour					
Ploughing the soil to sun dry	Peson-day	0.35	30000.0	10500.0	100.0
Digging the pits for mango trees	Peson-day	5.8	30000.0	174000.0	100.0
Applying fertilizers and lime	Peson-day	0.35	30000.0	10500.0	100.0
Plant material					
Mango trees	Tree	25.0	8000.0	200000.0	100.0
Eggplant seeds	Bag	1.0	8000.0	8000.0	100.0
Fertilizers and biocides					
lime	kg	25.0	2000.0	50000.0	100.0
Compost from biodigester	Tank	50.0	2000.0	100000.0	100.0
Construction material					
Hoe	Piece	2.0	20000.0	40000.0	100.0
Handle basket	Paire	1.0	7000.0	7000.0	100.0
Soil digger	Piece	1.0	25000.0	25000.0	100.0
Total costs for establishment of the Technology				**625000.0**	

Maintenance activities

1. Check the crops regularly to make sure the crops not fall down or demage by insects. (Timing/ frequency: Once every 5 days)
2. Soil preparation after each short-term crop's harvest (Timing/ frequency: After harvest)
3. Making small pit around the mango tree (Timing/ frequency: When mango tree getting bigger)
4. Apply compost and fertilzer KCL(15-15-15) (Timing/ frequency: May and October)
5. Watering the crops (Timing/ frequency: Daily especially in dry season)
6. Purchase water pumping machine (Timing/ frequency: After growing mango trees)

Total maintenance costs (estimation)
2800000.0

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate
Average annual rainfall in mm: 1138.2
In 2015 the annual rainfall was 1138.2 mm, in 2014 1696.50, in 2013 1661.8 mm.
Name of the meteorological station: Department of Meteorology, Ministry of Water Resources and Meteorology (2015)
There are two seasons: dry and rainy seasons

Slope
- ☑ flat (0-2%)
- ☐ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☑ plateau/plains
- ☐ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☑ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☑ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☐ very deep (> 120 cm)

Soil texture (topsoil)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☐ medium (loamy, silty)
- ☑ fine/ heavy (clay)

Topsoil organic matter content
- ☐ high (>3%)
- ☐ medium (1-3%)
- ☑ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☑ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☑ good
- ☐ medium
- ☐ poor/ none

Water quality (untreated)
- ☑ good drinking water
- ☐ poor drinking water (treatment required)
- ☐ for agricultural use only (irrigation)
- ☐ unusable

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☐ Yes
- ☑ No

Species diversity
- ☐ high
- ☐ medium
- ☑ low

Habitat diversity
- ☐ high
- ☐ medium
- ☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☐ mixed (subsistence/ commercial
- ☑ commercial/ market

Off-farm income
- ☐ less than 10% of all income
- ☐ 10-50% of all income
- ☑ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☐ poor
- ☐ average
- ☑ rich
- ☐ very rich

Level of mechanization
- ☑ manual work
- ☐ animal traction
- ☑ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative
- ☐ employee (company, government)

Gender
- ☑ women
- ☐ men

Age
- ☐ children
- ☐ youth
- ☑ middle-aged
- ☐ elderly

Area used per household
- ☐ < 0.5 ha
- ☐ 0.5-1 ha
- ☐ 1-2 ha
- ☑ 2-5 ha
- ☐ 5-15 ha
- ☐ 15-50 ha
- ☐ 50-100 ha
- ☐ 100-500 ha
- ☐ 500-1,000 ha
- ☐ 1,000-10,000 ha
- ☐ > 10,000 ha

Scale
- ☐ small-scale
- ☑ medium-scale
- ☐ large-scale

Land ownership
- ☐ state
- ☐ company
- ☐ communal/ village
- ☐ group
- ☐ individual, not titled
- ☑ individual, titled

Land use rights
- ☐ open access (unorganized)
- ☐ communal (organized)
- ☐ leased
- ☑ individual

Water use rights
- ☐ open access (unorganized)
- ☐ communal (organized)
- ☐ leased
- ☑ individual

Access to services and infrastructure

health	poor	☑	☐	☐	good
education	poor	☑	☐	☐	good

technical assistance	poor			✓	good
employment (e.g. off-farm)	poor		✓		good
markets	poor			✓	good
energy	poor			✓	good
roads and transport	poor			✓	good
drinking water and sanitation	poor			✓	good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased						✓		increased	Production is increased because in previous land no crops cultivation, but now there are more than one crop.
crop quality	decreased							✓	increased	The quality of crop is improved by using animal manure and compost.
risk of production failure	increased							✓	decreased	The risk of production failure is reduced due to having more than one crop. Before, the farmer had no crops so he had no crop production for selling on the market.
land management	hindered					✓			simplified	Before it is the infertile soil but after more crops is cultivated and using compost, the soil fertility is improved.
demand for irrigation water	increased		✓						decreased	Crop cultivation under mango tree is needed watering everyday.
expenses on agricultural inputs	increased						✓		decreased	The farmer has his own cows, so she could have cow manure as the natural fertilizer for the crops. In addition, she also has biodigester which could get the slurry to produce compost without buying fertilizer from supplier.
farm income	decreased						✓		increased	Generating regular income from selling eggplant.
diversity of income sources	decreased						✓		increased	There are short-term and long-term crops cultivation so it can generate annual and monthly income.
workload	increased		✓						decreased	Regular maintenance of the crops is needed.

Socio-cultural impacts

food security/ self-sufficiency	reduced						✓		improved	Household consumption and selling.
health situation	worsened						✓		improved	Compost from biodigester is good for both the producer and consumers.
recreational opportunities	reduced						✓		improved	Having some trees provides shade, it is less hot and fresh air.

Ecological impacts

evaporation	increased						✓		decreased	Due to rice straw mulching and shade of the mango trees.
soil moisture	decreased						✓		increased	Due to rice straw mulching.
soil cover	reduced						✓		improved	Due to vegetation cover as eggplant and mango trees.
soil compaction	increased							✓	reduced	When the rice straw rots, it become organic fertilizer benefit to the soil. Moreover, cow manure and compost helps to improve the soil structure.
soil organic matter/ below ground C	decreased						✓		increased	The rotten of rice straw, the application of cow manure and compost could increase the soil organic matter.
beneficial species (predators, earthworms, pollinators)	decreased						✓		increased	The beneficial species are increased through slurry from biodigester and application of animal manure. The land user notices to increase of earthworm, ant, termite, small frog etc.
pest/ disease control	decreased			✓					increased	Pests still occur but not many.
drought impacts	increased					✓			decreased	Drought impacts is reduced due to rice straw

mulching and shade from mango tree.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative							✓	very positive

Benefits compared with maintenance costs

Short-term returns	very negative					✓			very positive
Long-term returns	very negative						✓		very positive

While the mango has not produce fruits, harvest is done with the short-term crops.

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed

How the Technology copes with these changes/extremes

Gradual climate change

annual temperature increase	not well at all				✓		very well	
seasonal temperature increase	not well at all				✓		very well	Season: dry season
seasonal rainfall decrease	not well at all				✓		very well	Season: wet/ rainy season
Variation in rainfall pattern increase	not well at all			✓			very well	

Climate-related extremes (disasters)

local rainstorm	not well at all			✓			very well
heatwave	not well at all				✓		very well
drought	not well at all				✓		very well
epidemic diseases	not well at all				✓		very well
insect/ worm infestation	not well at all			✓			very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☑ 0-10%
☐ 10-50%
☐ 50-90%
☐ 90-100%

Has the Technology been modified recently to adapt to changing conditions?

☑ Yes
☐ No

To which changing conditions?

☑ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

Rice straw mulching reduces evaporation.

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Possibility to grow other crops with the mango trees.
- When watering the eggplants, it also benefits the mango trees.

Strengths: compiler's or other key resource person's view

- The land is used effectively as it will take at least three years before the mango trees start to provide a harvest.
- Rice straw helps to retain soil moisture, reduces evaporation and improves nutrient cycling.
- Generation of a substantial income for the family.
- The soil is not degraded by growing short term crops, crop rotation and using cow manure, composting and slurry from biodigester.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Some carterpillars could damage the eggplants. → Manually pick off the insects' eggs and do not apply pesticide which could cause health risks.
- Insecure market demand; while eggplants are in peak production. → Try to access various markets and mobile sale of the product at other people's households.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- When the mango trees are quite mature could not grow eggplant between trees. → Select short-term crops that only need a smaller amount of light such as turmeric galanga.
- Require compost and a biodigester → Promote animal husbandry including cows, pigs and poultry.

REFERENCES

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Date of documentation: May 17, 2017

Last update: March 1, 2018

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_2255/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)


Intercropping of cashew nut trees with peanut on the uplands of Tbaeng Mean Chey District (Mr. Tim Sophea)

Agroforestry-intercropping of peanut between cashew nut trees in upland areas (Cambodia)

Peanut and cashew nut trees

DESCRIPTION

Intercropping of annual cropping (peanut) with cashew trees farm aims to fill the free space of land between cashew trees. This kind of crop cover prevents soil erosion and improves soil fertility. At the same time peanut cultivation is economically interesting for the farmers as it enjoys high market demand.

Peanut belongs to the family of Leguminosae (scientific name: Aarachishypogeae L) and contains many beneficial substances. The grain of peanut contains nutrients such as protein, calcium, vitamin B, and acid glutamine and its oil content at 40-60 percent is very high. The average yield of peanut is 0.73 ton/hectare (Cambodian Agricultural Research and Development Institute, 2006). Cambodians are growing it at household scale or on large farms.

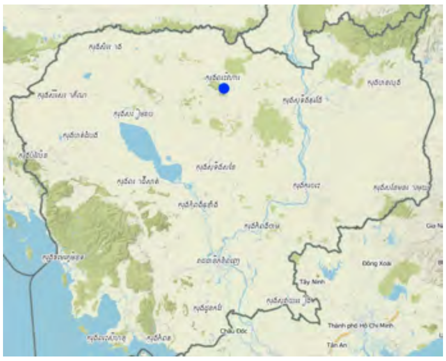
Peanut can grow on many soil types especially on sandy soils mixed with alluvial soil (alluvial soils easily absorb water). The plant requires much sunlight as lacking light delays the plant growing. Adequate water is another need of the plant - not too much and not too little water. Peanuts grow from April to May and from September to October on the uplands and in November along the river after water has receded. The time of harvesting depends on the seed variety. Short term seeds can be harvested after 90 - 100 days and long term seeds after 120 - 140 days (Agritoday, 2016,Yayo, 2016).

Cashew belongs to the family of Asanardiaceae (scientific name: Anacardiumoccidentale L, Royal University of Agriculture, 2006). Cashew trees are grown in many tropical countries. The nutrition value of cashew nuts is high at about 500 calories per 100 gr. The first worthwhile harvest begins after 3 or 4 years (first yield 2.5 to 3 kilogram per tree) but can be started already with low yield after second year. But seven years after planting the yield of this evergreen tree remains constantly high nearly until it's cut down after 25 years. In 2017, fresh cashew nuts got 8500 riel per kilogram (Agritoday, 2017).

As main purposes of the peanut as intercrop between cashew trees can be seen in the reduction of weed at 50 percentage and in the increase of additional income (MoE,2016). Miss. Uth Vin living in the uplands of Preah Vihear province (Cambodia) is one of the farmers engaged in this agroforestry system. Before she started on some plots the land was degraded forest land. Firstly she converted it into a mono-cropping system (cassava, banana, mung bean, and soy bean). In 2016 she changed to cashew trees combined with peanuts.

The main benefits of this intercropping system are:
1. The technology meets the farmer's ultimate economic need of enough cultivable land, as - to a certain extent - also degraded land can be cultivated by this technique and thus, create yield to improve the household income.
2. Before the farmers gets enough yields from cashew trees (after 3 years), peanuts provide them immediate income (yield after 3 month/2 harvests). On one hectare, peanut can provide a net income of 3,000,000 Riel (4000 Riel per kilogram).
As peanuts need enough sunlight, the intercropping must be stopped after 3 years, because the branches of the cashew trees provide too much shadow that is not convenient to peanut growing.

LOCATION



Location: The farm is 2 kilometers in distance from the mountain., BengKoang Village, PreahKhleang Commune,Tbaeng Mean Chey District, Preah Vihear Province., Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites
- 104.9932, 13.67273

Spread of the Technology: evenly spread over an area

Date of implementation: 2016

Type of introduction
☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☐ through projects/ external interventions

Beside the benefits already mentioned, the intercropping of peanut can improve soil fertility because the plant takes nitrogen from the air and "fix" it into the soil via its roots and by support of Rhizobium bacteria. After harvesting, the plant residues are ploughed into the soil as organic fertilizer. Thus, it is a very important green manure, which reduces the application of chemical fertilizers. Weed control at the first years of cashew growing is important as well. This also can be attained by the peanut cover plantation on the ground. Last but not least, peanut and cashew trees are crops which prevent soil erosion by water.


Cashew nut farm (Mr. Tim Sophea)


Peanut and cashew nut trees in distance of 2 kilometers from the mountain. (Mr. Tim Sophea)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☐ conserve ecosystem
☑ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use

Mixed (crops/ grazing/ trees), incl. agroforestry - Agroforestry
Main products/ services: Cashew intercropped by peanut.

Water supply

☑ rainfed
☐ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 2
Land use before implementation of the Technology: Degraded forest then converted to cassava farm, banana, mung bean or soy bean farm.
Livestock density: n.a.

Purpose related to land degradation

☑ prevent land degradation
☐ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion

biological degradation - Bc: reduction of vegetation cover

water degradation - Ha: aridification

SLM group

- agroforestry
- improved ground/ vegetation cover

SLM measures

agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility

TECHNICAL DRAWING

Technical specifications

The implementation area of this technology is 10.000 square meters (width: 100 meters, length: 100 meters). 220 cashew trees has been planted on the plot. The space between the trees is 7 meters and the row distance in another 7 meters.

The pit for growing cashew trees is 30 centimeters in width, 30 long and 30 cm deep. The slope of the area is around 1.5-3 degree and it is about 2 kilometers from the mountain.

The peanut is planting by direct seedling by planting 3 seeds per hole(the hole is 3-4 cm in depth) by line with a hole spacing of 20 cm and a row spacing of 30 cm. In 10.000 square meters, the land users uses about 200 kg of peanut seeds.

Author: Miss. Om Sovanny

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **1 hectare** ; conversion factor to one hectare: **1 ha = 1 hectare= 10000 square meters**)
- Currency used for cost calculation: **KHR**
- Exchange rate (to USD): 1 USD = 4000.0 KHR
- Average wage cost of hired labour per day: 20000

Most important factors affecting the costs

General high expenses for the establishment and for the maintenance of the technology. Cashew trees provide fruit in the 3rd year and whereas peanuts can be harvested within 3 months. Normally from the moment cashew trees provide fruits, farmers could not grow peanut on the same plot anymore.

Establishment activities

1. Ploughing the soil (Timing/ frequency: January-March)
2. Digging the pits for growing cashew trees (Timing/ frequency: July)
3. Applying organic fertilizer (Timing/ frequency: July)
4. Planting and growing peanut (Timing/ frequency: July)

Establishment inputs and costs (per 1 hectare)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
Plough the soil	hectare	1.0	60000.0	60000.0	100.0
Growing peanut by direct seedling	Person-day	40.0	20000.0	800000.0	100.0
Equipment					
Dig pits for growing cashew trees	Pit	220.0	600.0	132000.0	100.0
Hoe	Piece	10.0	35000.0	350000.0	100.0
Big knifes	Piece	5.0	50000.0	250000.0	100.0
Spade	Piece	10.0	35000.0	350000.0	100.0
Plant material					
Cashew trees	Tree	220.0	3000.0	660000.0	100.0
Peanut seeds	Kilogram	200.0	4700.0	940000.0	100.0
Fertilizers and biocides					
Fertilizer	Kilogram	25.0	3000.0	75000.0	100.0
Total costs for establishment of the Technology				**3617000.0**	

Maintenance activities

1. Spray to improve cashew trees (leave) and pesticide (Timing/ frequency: One time per week)
2. Apply fertilizer on cashew tree root (Timing/ frequency: 6 times per year)
3. Weeding on cashew tree root (Timing/ frequency: 3 times per year)
4. Spay to improve peanut buddy and leave (Timing/ frequency: When peanut grow for 20 days)
5. Spay chemical fertilizer to improve flower and stem of peanut (Timing/ frequency: 3 times per 3 moths (one cycle of crop))
6. Weeding on peanut root (Timing/ frequency: 2 times per three months)
7. Harvesting peanut (Timing/ frequency: After three months)
8. Harvesting cashew nut (Timing/ frequency: After 3 years)

Maintenance inputs and costs (per 1 hectare)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
Spray to improve fruit, leave and pesticide (Cashew)	Time	32.0	40000.0	1280000.0	100.0
Apply chemical fertilizer on cashew root	person-day	36.0	20000.0	720000.0	100.0
Weeding on cashew root.	Person-day	45.0	20000.0	900000.0	100.0
Spray chemical fertilizer on peanut to improve leave and stem.	time	3.0	40000.0	120000.0	100.0
Equipment					
Pesticide spraying machine.	Piece	1.0	400000.0	400000.0	100.0
Pesticide spraying equipment using by hand.	Piece	1.0	20000.0	20000.0	100.0
Fertilizers and biocides					
Chemicals to improve cashew	Box	2.0	25000.0	50000.0	100.0
Chemicals to improve stem, flower (peanut)	Box	1.0	25000.0	25000.0	100.0
Chemicals to improve stem of peanut	package	10.0	2500.0	25000.0	100.0
Construction material					
Buy a tent for sun drying peanuts	piece	5.0	24000.0	120000.0	100.0
Buy bag for peanuts	piece	700.0	1000.0	700000.0	100.0
Big basket for collecting peanuts	piece	3.0	15000.0	45000.0	100.0
Other					
Weeding on peanut root.	time	20.0	20000.0	400000.0	100.0
Harvesting peanut.	person-day	70.0	20000.0	1400000.0	100.0
collect peanut seed.	Person-day	60.0	20000.0	1200000.0	100.0
Hire labor to select peanut seed.	Person-day	10.0	20000.0	200000.0	100.0
Hire labor to pick up cashew nut.	Kilogram	1000.0	700.0	700000.0	100.0
Total costs for maintenance of the Technology				8305000.0	

NATURAL ENVIRONMENT

Average annual rainfall
☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☑ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone
☐ humid
☑ sub-humid
☐ semi-arid
☐ arid

Specifications on climate
Average annual rainfall in mm: 1429.3
Annual rainfall in 2015 was1429.3 mm and in 2014, the annual rainfall was 1647.3 mm.
Name of the meteorological station: Ministry of Water Resources and Meteorology 2015

Slope
☐ flat (0-2%)
☑ gentle (3-5%)
☐ moderate (6-10%)
☐ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☐ 0-100 m a.s.l.
☑ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☐ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☑ very deep (> 120 cm)

Soil texture (topsoil)
☐ coarse/ light (sandy)
☐ medium (loamy, silty)
☑ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☐ medium (loamy, silty)
☑ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☑ medium (1-3%)
☐ low (<1%)

Groundwater table
☐ on surface
☑ < 5 m
☐ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☐ good
☐ medium
☑ poor/ none

Water quality (untreated)
☐ good drinking water
☐ poor drinking water (treatment required)
☑ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☐ high
☐ medium
☑ low

Habitat diversity
☐ high
☐ medium
☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☐ mixed (subsistence/

Off-farm income
☐ less than 10% of all income
☑ 10-50% of all income

Relative level of wealth
☐ very poor
☐ poor

Level of mechanization
☑ manual work
☐ animal traction

☐ commercial
☑ commercial/ market

☐ > 50% of all income

☑ average
☐ rich
☐ very rich

☑ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☑ women
☐ men

Age
☐ children
☐ youth
☑ middle-aged
☐ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☑ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☐ small-scale
☑ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual
☑ Rely on rainfall

Access to services and infrastructure

health	poor	✓			good
education	poor		✓		good
technical assistance	poor		✓		good
employment (e.g. off-farm)	poor	✓			good
markets	poor			✓	good
energy	poor			✓	good
roads and transport	poor			✓	good
drinking water and sanitation	poor			✓	good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased						✓		increased	Before, she only cultivated one crop e.g. banana, cassava or soy bean. Now by planting two crops and especially, by planting peanut which grows two times per year, she gets a higher production.
crop quality	decreased						✓		increased	Monocropping is rather confronted with diseases that reduces the crop quality (e.g. banana is often prone by mealybugs), while the simultaneous cultivation of two crop species like cashew and peanut reduces diseases due to beneficial meachnisms set in motion (e.g. modification of the microclimate)
risk of production failure	increased						✓		decreased	By the intercropping technology more than one crop grows on the agricultural plot, which reduces the risk production failure.
product diversity	decreased						✓		increased	She plants now two crops simultaneously on the plot.
land management	hindered					✓			simplified	Intercropping could prevent soil erosion from water and in addition, it also reduces weeds.
expenses on agricultural inputs	increased		✓						decreased	Despite of the reduced need of weeding, the growing of more than one crop variety needs a lot of fertilizer, labor force, and fine tuning of pesticide use.
farm income	decreased						✓		increased	The market prices of cashew and peanuts are actually higher than the price of banana. Due to peanut planting in combination with the cashew growing the farmer avoids the income gap related to the late harvest of cashews (only in the 3rd year).
diversity of income sources	decreased						✓		increased	
economic disparities	increased				✓				decreased	
workload	increased			✓					decreased	Land user has to maintain both peanut and cashew nut trees. Therefore she spend more time to apply fertilizers, pesticides to check all crops, if there is any disease or insect outbreak at all growing stages.

Socio-cultural impacts

food security/ self-sufficiency	reduced						✓		improved	Peanut provides short term yield, before the cashew

nut trees produce enough fruits.

health situation	worsened	☐☐☐☐✓☐☐	improved	The nutrition value from both crops (cashew and peanut) is high and very beneficial to the human health.
cultural opportunities (eg spiritual, aesthetic, others)	reduced	☐☐☐✓☐☐☐	improved	Many land users learn from each other to practice such kinds of Agroforestry systems. It is now popular in the upland areas of the Preah Vihear Province.
SLM/ land degradation knowledge	reduced	☐☐☐☐☐✓☐	improved	The land user understands now the benefit of the intercropping system which avoids free space or bare land. She sees e.g., that the planting of peanuts between the trees avoids soil erosion by water and also, she recognizes that residues of peanut can improve soil fertility.
conflict mitigation	worsened	☐☐☐✓☐☐☐	improved	The farmer was never involved in conflicts related to this technology. The farmers in this reagion are very open to share their knowledge.

Ecological impacts

soil moisture	decreased	☐☐☐☐✓☐☐	increased	The soil cover by cashew trees and peanuts reduces the evaporation to the atmosphere and retain the moisture in the soil.
soil cover	reduced	☐☐☐☐☐☐✓	improved	Due to the peanut plants which cover the ground around the cashew trees entirely.
soil compaction	increased	☐☐☐☐☐✓☐	reduced	Peanut residues reduce soil compaction.
soil organic matter/ below ground C	decreased	☐☐☐☐✓☐☐	increased	Peanut residue provide as source of organic matter which increases the activity of soil organisms and improves therefore the soil fertility.
plant diversity	decreased	☐☐☐☐✓☐☐	increased	Compared to the former monocropping, more than one crop is planted now (peanut and cashew nut trees).
invasive alien species	increased	☐☐☐☐☐✓☐	reduced	Unknown disease occured on banana leaves turning them yellow. It might come from unknown viruses.
beneficial species (predators, earthworms, pollinators)	decreased	☐☐☐☐☐✓☐	increased	The peanut residues increases the food source for decomposing soil organisms and therefore the number of beneficial species such as earthworms, ant, termites etc. raised.
pest/ disease control	decreased	☐✓☐☐☐☐☐	increased	Less pest and disease due to the beneficial meachnism set in motion in the soil and on the microclimate by the intercropping of cashew trees and peanuts.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐☐☐✓	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐☐☐✓	very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes			
Gradual climate change				
annual temperature increase	not well at all	☐☐✓☐☐	very well	
seasonal temperature increase	not well at all	☐☐☐✓☐	very well	Season: wet/ rainy season
seasonal temperature increase	not well at all	☐☐✓☐☐	very well	Season: dry season
annual rainfall increase	not well at all	☐☐✓☐☐	very well	
seasonal rainfall decrease	not well at all	☐☐✓☐☐	very well	Season: wet/ rainy season

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☐ 1-10%
☐ 10-50%
☑ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Gain an additional income from the peanuts which can be harvested already within three months.
- Provide an additional income before the cashew trees produce fruit. This can be used to help cover expenditure on crop maintenance and other daily expenses.

Strengths: compiler's or other key resource person's view

- Peanuts are a short term crop which can be harvested within 3 months already.
- Growing crops on the open space of land prevent soil erosion caused by water and wind.
- Peanuts are the kind of crop that improves soil fertility and makes the soil not compact, as after harvesting, the peanut residue is ploughed into the soil.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Require a lot of labor for maintenance, such as spraying against pest and use of chemicals to improve leaves and stems. → Hire labor

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- The cropping heavily relies on rainfall. → Dig a well or pond for water storage which could reduce the risk of crop failure during periods of drought.
- The cultivation of a short term crop such as peanuts can only be done before the cashew trees become more sizable. After three or four years the cashew trees will provide too much shade and so it is not possible to continue to grow this short term crop. → Grow crops that do not need a lot of sunlight such as turmeric or galanga etc.

REFERENCES

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Phol Prom (prom.phol2017@gmail.com) - Chief of District Office of Agriculture, Forestry and Fisheries, Kuleaen
Vin Uth (NA) - land user
Chhlath Prach (NA) - Official from District Office of Agriculture, Forestry and Fisheries,Choam Khsant

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_2315/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

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Pineapple cultivation between mango trees and orange trees (Mr. Tim Sophea)

Agroforestry: intercropping of pineapple between orange and mango trees (Cambodia)

DESCRIPTION

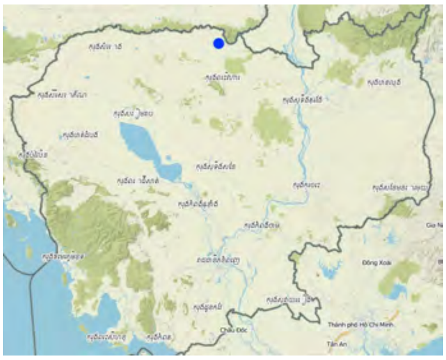
The agroforestry practice based on intercropping of pineapple between mango and orange trees helps to maintain soil nutrients while enhancing potential economic benefits through multiple cropping to meet the market demand.

The increase in forest cover loss has been dramatic, especially in plateau areas due to population growth and agricultural land expansion. The net result is seen in increased soil erosion and decreasing soil fertility, leading to land degradation (MPWT et al., 2016). Thus, agroforestry is being promoted based on its potential benefits through reducing soil erosion, increasing the economic returns, improved crop yields, improved soil fertility, and soil moisture. Agroforestry is the process of planting vegetables or other crops known as annual crops with long-term crops such as mango and orange trees (MoE et al., 2016).

Farmers adopt agro-forestry intercropping as a technique for reducing the application of chemical fertilizers, more economic use of water and soil moisture, higher yields and higher income. Pineapple is a suitable crop for intercropping in the unused space between mango and oranges trees, because it is share tolerant and does not need much sunlight. Pineapple is also resistance to water logging (for up to 7 days). Occasionally, the areas closest to rivers can become flooded for about 24 hours after periods of heavy rain. Often farmers who adopt the practice of intercropping not use chemical fertilizers or pesticide because they rely on the potential benefits of crop residues, leaf material, small plants, and grass cutting. Normally, mango trees and oranges are the long-term crops, and when grown there is usually a large amount of unused spacing in the area where the trees are grown. If this area is not used for other crops, there is weed ingress which can be difficult to control. Therefore, the cultivation of pineapples in this space will provide an income source in the period before the mango and orange trees become productive. The intercropping also saves labour input for weed control and facilitates the maintenance of the land. Moreover, when mango trees and orange became mature trees, pineapples can continue to be grown as they are shade tolerant but little sunlight may of course lead to lower production. However, pineapples are a relatively new product for that locality's markets.

An examined block of land at Kouk Sralau Village, 2000 square meters in area (20 meters wide and 100 meters long), contained 10 orange trees and 14 mango trees, and about 1000 pineapple plants. The mango trees were planted in two rows on both edges of the land (one row contained about 6 to 7 trees). The oranges were planted in the middle, and then the pineapples between the mango and orange trees. When planting the mango trees 0.5 meter holes were dug with a depth of half a meter. The distance between the mango trees was 15 meters. Leaf and other waste materials that had been kept for about a year were used to fill the holes. The orange trees were planted in a small dike about 20 cm high and length 2m in square shape around the planting hole (the hole was the same size as mango's hole), with a 4 meter distance between the trees. The land was cultivated during April or May and the trees planted after some rain. Weeding was needed in 3 to 4 months period after planting, and a year later cow manure was added to provide a source of organic nutrients. The interrow planting of pineapple plants used a plant-to-plant interval of one meter (collate as triangles shape), with planting taking place into

LOCATION



Location: Kouk Sralau Village, Choam Khsant Commune, Choam Khsant District, Preah Vihear Province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites
- 104.92638, 14.21679

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 2007; 10-50 years ago

Type of introduction
☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☐ through projects/ external interventions

holes 20 cm wide and 10 cm deep. If deeper holes are used, often the pineapples will rot. As it normally takes 9 to 10 months before the pineapples can be harvested, only one pineapple crop is grown per year. After harvest, it took time about 1 to 2 month more before the copies growth (more than 10 leaves) bigger and ready as planting materials for the next plantation cycle. After, all pineapple residue is collected and buried in a part of the land to provide a later source of organic nutrients.


Pineapple cultivation between orange and mango trees (Mr. Tim Sophea)


Pineapple plants (Mr. Tim Sophea)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☐ reduce, prevent, restore land degradation
☑ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use

Mixed (crops/ grazing/ trees), incl. agroforestry - Agroforestry
Main products/ services: Mango, orange, pineapple

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 1

Land use before implementation of the Technology: In former times, this land was forest land, later it has been covered by rice and nowadays it used as agroforestry land.

Livestock density: n.a.

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion

water degradation - Ha: aridification

SLM group

- agroforestry
- improved ground/ vegetation cover

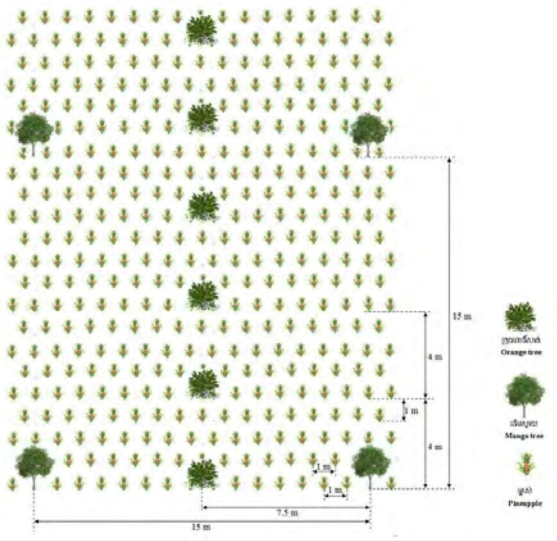
SLM measures

agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility

TECHNICAL DRAWING

Technical specifications

The represented block of land, 2000 square meters in area, contains 10 orange trees and 14 mango trees, and about 1000 pineapple plants. The mango trees are planted in two rows on both edges of the land (one row contained about 6 to 7 trees). The oranges are planted in the middle, and then the pineapples between the mango and orange trees. When planting the mango trees 0.5 meter holes are dug with a depth of half a meter. The distance between the mango trees is 15 meters. Leaf and other waste materials that had been kept for about a year were used to fill the holes. The orange trees are planted in a small dike about 20 cm high and length 2m in square shape around the planting hole, with a 4 meter distance between the trees. The interrow planting of pineapple plants used a plant-to-plant interval of one meter (collate as triangles shape), with planting taking place into holes 20 cm wide and 10 cm deep. If deeper holes are used, often the pineapples will rot.



Author: Dr. So Than

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **20 X 100= 2000 square meters**)
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 20000 Riel

Most important factors affecting the costs

Gasoline for water pumping

Establishment activities

1. Plow 3 times and drying for 2 to 3 days (Timing/ frequency: April-May and after raining)
2. Harrow the soil and drying it for 2 to 3 days (Timing/ frequency: April to May)
3. Dig the holes for cultivation (Timing/ frequency: April to May)
4. Mango tree cultivation (Timing/ frequency: April to May)
5. Orange tree cultivation (Timing/ frequency: April to May)
6. Pineapple plantation (Timing/ frequency: April to May)

Establishment inputs and costs (per 20 X 100= 2000 square meters)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Plowing	person-day	7.5	20000.0	150000.0	100.0
Digging the holes	person-day	3.0	20000.0	60000.0	100.0
Equipment					
Shovel	piece	1.0	8000.0	8000.0	100.0
Hoe	piece	1.0	15000.0	15000.0	100.0
Spade	piece	2.0	13000.0	26000.0	100.0
Plant material					
Mango plants	plant	15.0	4000.0	60000.0	100.0
Orange plants	plant	10.0	15000.0	150000.0	100.0
Total costs for establishment of the Technology				**469000.0**	

Maintenance activities

1. Watering mango and orange trees (Timing/ frequency: Every week)
2. Watering pineapple plants (Timing/ frequency: Every week)
3. Weeding (Timing/ frequency: Every 20 days)
4. Manure spreading (Timing/ frequency: Once a year)

Maintenance inputs and costs (per 20 X 100= 2000 square meters)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Watering	person-day	52.0	20000.0	1040000.0	100.0
Weeding	person-day	20.0	20000.0	400000.0	100.0
Manure spreading	person-day	1.0	20000.0	20000.0	100.0
Equipment					
Water pumping machine	Piece	1.0	2000000.0	2000000.0	100.0
Lawn mowers	Piece	1.0	300000.0	300000.0	100.0
Two-wheel tractor	Piece	1.0	4700000.0	4700000.0	100.0
Fertilizers and biocides					
Cow and buffalo manure	kg	100.0	200.0	20000.0	100.0
Construction material					
Gasoline for water pumping	liter	30.0	3500.0	105000.0	100.0
Gasoline for cutting weeds	liter	260.0	3500.0	910000.0	100.0
Total costs for maintenance of the Technology				**9495000.0**	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate

Average annual rainfall in mm: 1429.3
The annual rainfall in 2015 is 1429.3 mm. In 2014 is 1647.3 mm.
Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)
There are 2 seasons, dry season and rainy season.

Slope
- ☑ flat (0-2%)
- ☐ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☑ plateau/plains
- ☐ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☑ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☐ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☑ very deep (> 120 cm)

Soil texture (topsoil)
- ☐ coarse/ light (sandy)
- ☐ medium (loamy, silty)
- ☑ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☐ medium (loamy, silty)
- ☑ fine/ heavy (clay)

Topsoil organic matter content
- ☑ high (>3%)
- ☐ medium (1-3%)
- ☐ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☑ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☑ good
- ☐ medium
- ☐ poor/ none

Water quality (untreated)
- ☐ good drinking water
- ☐ poor drinking water (treatment required)
- ☑ for agricultural use only (irrigation)
- ☐ unusable

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☑ Yes
- ☐ No

Species diversity
- ☐ high
- ☐ medium
- ☐ low

Habitat diversity
- ☐ high
- ☐ medium
- ☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☐ mixed (subsistence/ commercial
- ☑ commercial/ market

Off-farm income
- ☑ less than 10% of all income
- ☐ 10-50% of all income
- ☐ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☐ poor
- ☑ average
- ☐ rich
- ☐ very rich

Level of mechanization
- ☑ manual work
- ☐ animal traction
- ☑ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative
- ☐ employee (company, government)

Gender
- ☐ women
- ☑ men

Age
- ☐ children
- ☐ youth
- ☐ middle-aged
- ☑ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☑ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☑ small-scale
☐ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual
☑ Nephew's land

Water use rights
☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor		✓		good
education	poor			✓	good
technical assistance	poor	✓			good
employment (e.g. off-farm)	poor	✓			good
markets	poor	✓			good
energy	poor	✓			good
roads and transport	poor			✓	good
drinking water and sanitation	poor			✓	good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased			✓					increased	Before he was growing more crops than nowadays, which reduces slightly the crop production. But the market demand for the products is high.
crop quality	decreased				✓				increased	There are fruit flies affecting the fruits in last 7 to 8 years.
risk of production failure	increased					✓			decreased	As long-term and short-term crops are now cultivated, the risk of failure has been reduced slightly. The famer doesn't use chemical fertilizer or pesticides.
product diversity	decreased					✓			increased	There are 3 kinds of crops on plot now
land management	hindered						✓		simplified	There are 2 types of crops as long-term and short-term cropping. The improved soil cover reduces therefore weeding and water consumption control.
expenses on agricultural inputs	increased			✓					decreased	Because of longer need of watering for peneapples and therefore higher costs for fuel needed to run the water pump.
farm income	decreased						✓		increased	The production is slightly lower but the farmer gets better prices because the market demand of mango, orange and pineapple is high.
workload	increased					✓			decreased	Workload decreased because of less weeding and reduction of irrigation control.

Socio-cultural impacts

health situation	worsened							✓	improved	Mixed cropping usually needs pesticide, but on pineapple growing it is not necessary.
SLM/ land degradation knowledge	reduced						✓		improved	He learned how to change from chemical fertilizers to organic fertilizers.

Ecological impacts

soil moisture	decreased					✓			increased	Soil moisture is increased because land is covered by crops.
soil cover	reduced					✓			improved	Long-term and annual crops is planted all year round.
soil crusting/ sealing	increased						✓		reduced	Soil crusting or sealing is reduced due to the cover by fruit trees that increases soil moisture.
soil compaction	increased						✓		reduced	As fruit trees or long-term crops are planted the roots reduce soil compaction more than than vegetables.
nutrient cycling/ recharge	decreased						✓		increased	Nutrient cycling is increased because crop residues and leaf material remain on the soil.

soil organic matter/ below ground C	decreased						✓		increased	Because nowadays he used organic fertilizer, instead of chemical fertilizer which has increased the soil organic matter in the soil.
plant diversity	decreased						✓		increased	Long-term cropping and annual cropping is planted.
invasive alien species	increased				✓				reduced	
beneficial species (predators, earthworms, pollinators)	decreased						✓		increased	The beneficial species increased due to the organic fertilizer application.
pest/ disease control	decreased				✓				increased	
drought impacts	increased						✓		decreased	The roots of the fruit trees and the pineapples go deep into the soil and the pineapple plants cover the soil and bring shadow, that protect the soil from drying out.
micro-climate	worsened						✓		improved	The plant residues and the plants as a whole regulate soil evapotranspiration and temperature.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative			✓					very positive
Long-term returns	very negative					✓			very positive

Benefits compared with maintenance costs

Short-term returns	very negative			✓					very positive
Long-term returns	very negative					✓			very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes							
Gradual climate change								
annual temperature increase	not well at all						very well	Answer: not known
seasonal temperature increase	not well at all				✓		very well	Season: wet/ rainy season
seasonal temperature increase	not well at all				✓		very well	Season: dry season
annual rainfall decrease	not well at all						very well	Answer: not known
seasonal rainfall decrease	not well at all				✓		very well	Season: wet/ rainy season
The climate can extremely change due to deforestation, next 10 years it would be change to local crops such as mango trees.	not well at all						very well	
Climate-related extremes (disasters)								
local thunderstorm	not well at all						very well	Answer: not known
heatwave	not well at all				✓		very well	
cold wave	not well at all				✓		very well	
extreme winter conditions	not well at all				✓		very well	
general (river) flood	not well at all			✓			very well	
flash flood	not well at all			✓			very well	
epidemic diseases	not well at all			✓			very well	
Other climate-related consequences								
extended growing period	not well at all			✓			very well	
reduced growing period	not well at all			✓			very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology	Of all those who have adopted the Technology, how many have done so without receiving material incentives?
☑ single cases/ experimental	☐ 0-10%
☐ 1-10%	☐ 10-50%
☐ 10-50%	☐ 50-90%
☐ more than 50%	☑ 90-100%

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Getting an improved income and enough crops for the family
- Healthy production for family needs and for the consumers
- Getting increased benefits and reducing labout input, for the watering a moisture source can be provided for pinapples, mango and orange trees.
- All crops residues are buried in the soil to improve the soil fertility.

Strengths: compiler’s or other key resource person’s view

- Many kinds of crops help to reduce the risk of production failure.
- Good product for the market because pineapples are sweet, easy to sell and has no competitors.
- Soil improvement is achieved by using cow and buffalo manure in combination with the leaves of trees (organic fertilizer).
- Pineapple residues after harvesting worked into the soil to improve the soil fertility.
- There is no adverse health impacts because no chemicals and pesticides are used in the system.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Fruit flies still exist → No resolution yet

Weaknesses/ disadvantages/ risks: compiler’s or other key resource person’s view → how to overcome

- Still a large labour input needed for weed management.
  → Continue to do it conveniently

REFERENCES

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Date of documentation: June 22, 2017

Last update: Jan. 8, 2018

Resource persons
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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_2843/

Linked SLM data
n.a.

Documentation was faciliated by
Institution

- Royal University of Agriculture (RUA) - Cambodia

Project

- Scaling-up SLM practices by smallholder farmers (IFAD)

Key references

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- Agritoday. (2016). Pineapple plantation technique. In Khmer.: Retrieved November 01 2017 from http://agritoday.com/techniques/article/2103.html
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Orange with chili and banana that surround by papaya (Mr. Sok Pheak)

Agroforestry: Intercropping of vegetables between orange trees (Cambodia)

Mixed cropping

DESCRIPTION

Intercropping of chilies (or other short-term crops) between young orange trees is a type of agro-forestry system which increases income, makes ultimate use of land resources, saves time for maintenance and irrigation, and improves soil fertility by using crop residue with cow manure as fertilizer, thereby reducing the use of chemicals.

Chili can be seen as a short-term crop that can be harvested soon after plantation. Farmers plant such short term crops to support their family's income (Pov, 2016). Oranges are a long-term crop that can be fully harvested after six years and then continue to be harvested for a long time. The more the orange trees are mature, the more they are able to produce. Furthermore, they do not require a great deal of maintenance and there is a good market demand for oranges (CEDAC, 2011). Growing chilies between young orange trees is known as an agro-forestry system that gives rise to a great number of benefits including an increase in the efficiency of land use, a saving of time otherwise spent on maintenance and irrigation, and also it improves the soil quality and prevents land degradation. Moreover it is an improvement in crop production that helps to generate more income for farmers (ECHO, 2007).

The purpose of implementing this technology, whereby other short-term crops (such as chilies, eggplants, and herbs) are seasonally intercropped between young orange trees is to economize time spent on maintenance, watering, and applying fertilizer on chilies. And oranges benefit, too. Assorted crops absorb different nutrients from the soil which enables the soil to remain balanced and fertile and also they do not interfere with the growth of the long-term crop. Additionally the use of crop residue with cow manure is a mean of improving the soil's fertility and it helps to reduce the use of chemical fertilizer. Alternatively this technology can also include the plantation of papaya and banana trees around the land as additional crops, which provide shade and help to control soil moisture for the other crops.

The farmer needs to plough the soil three times. After the first ploughing the soil has to be dried for four days, after the second ploughing for five days and after the final ploughing it should be dried seven days. If there is additional rainfall then extra days will be needed to get the soil dry. After that, holes need to be dug at a distance of 3.5 meters from each other in any direction. Each hole measures 30 X 40 centimeters and is 30 centimeters in depth. . Before the orange trees are planted the soil should be mixed with compost, consisting of vegetables or crop residue and cow manure. Twenty-five to thirty days after the chilies have sprouted they should be planted between the trees in a row with a gap of 1.2 meters and a distance of one meter from side to side. 2 month later the around 270 chilies plants are able to produce a yield of around 50 to 60 kg.. Once they are four to five months old, 100 to 200 kg can be harvested every 15 days for a period of 6 months. The market price of chilies is between 2000 to 4000 riel per kilogram.

One of the main advantages stated by the land user is to be able to balance the land shortage by using all of free space within the orange orchard. Another advantage is that weeds have less chance to grow. This saves labor time and generates better income. Due to crop rotation (different seasonal crops) he can maintain a good soil quality through a balanced absorption of the soil nutrients.

LOCATION

Location: Kampong Chlang village, Voat Ta Muem commune, Sangkae district, Battambang province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 103.18059, 13.02104

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 2016

Type of introduction

☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☐ through projects/ external interventions


Chili cultivation under orange tree (Mr. Sok Pheak)


Cultivation of banana and papaya to improve soil moisture (Mr. Sok Pheak)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- ☑ improve production
- ☑ reduce, prevent, restore land degradation
- ☐ conserve ecosystem
- ☐ protect a watershed/ downstream areas – in combination with other Technologies
- ☐ preserve/ improve biodiversity
- ☐ reduce risk of disasters
- ☐ adapt to climate change/ extremes and its impacts
- ☐ mitigate climate change and its impacts
- ☑ create beneficial economic impact
- ☐ create beneficial social impact

Land use

Mixed (crops/ grazing/ trees), incl. agroforestry - Agroforestry
Main products/ services: Oranges trees, chili and other short-term crops like eggplants and herbs.

Water supply

- ☐ rainfed
- ☑ mixed rainfed-irrigated
- ☐ full irrigation

Number of growing seasons per year: 2
Land use before implementation of the Technology: Mango trees plantation land
Livestock density: n.a.

Purpose related to land degradation

- ☑ prevent land degradation
- ☑ reduce land degradation
- ☐ restore/ rehabilitate severely degraded land
- ☐ adapt to land degradation
- ☐ not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

biological degradation - Bc: reduction of vegetation cover, Bl: loss of soil life

water degradation - Ha: aridification

SLM group

- rotational systems (crop rotation, fallows, shifting cultivation)
- improved ground/ vegetation cover

SLM measures

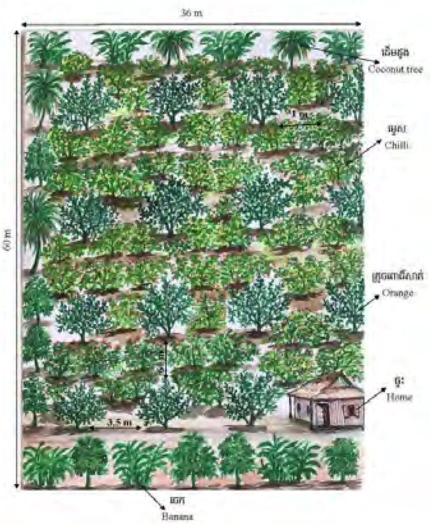
agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility

vegetative measures -

TECHNICAL DRAWING

Technical specifications

A farmer has applied this technique on a 2160 square meter piece of land (36 meters × 60 meters), planting 10 lines of orange trees with 15 trees in each line, at a distance of 3.5 meters in any direction between the orange trees. Chilies should be at a distance of 1.2 m between each row and a space of one meter between each plant.



Author: Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **2160 m2**)
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 20000 Riel

Most important factors affecting the costs

The farmer spends much for labor.

Establishment activities

1. Drill the well (Timing/ frequency: Dry season)
2. Plow and dry the soil (Timing/ frequency: When no rain (December))
3. Dig the the pits to cultivate orange trees (Timing/ frequency: January)
4. Planting the orange seedlings (Timing/ frequency: January)

Establishment inputs and costs (per 2160 m2)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Drill the well	person-day	40.0	20000.0	800000.0	100.0
Plow and dry the soil	person-day	7.5	20000.0	150000.0	100.0
Dig the the pits to cultivate orange trees	person-day	8.0	20000.0	160000.0	100.0
Equipment					
Material and pumping machine	piece	1.0	1000000.0	1000000.0	100.0
Spade	piece	2.0	30000.0	60000.0	100.0
Hoe	piece	3.0	20000.0	60000.0	100.0
Rope	kg	5.0	3700.0	18500.0	100.0
Plant material					
Orange trees	tree	150.0	5000.0	750000.0	100.0
Fertilizers and biocides					
Fertilizer	kg	500.0	400.0	200000.0	100.0
Animal manure	kg	1000.0	200.0	200000.0	100.0
Construction material					
Pipe	piece	50.0	12000.0	600000.0	100.0
Total costs for establishment of the Technology				**3998500.0**	

Maintenance activities

1. Planting the chili seedlings (Timing/ frequency: January)
2. Watering (Timing/ frequency: Every weeks)
3. Weeding (Timing/ frequency: Every 3 weeks)

Maintenance inputs and costs (per 2160 m2)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Planting the chili seedlings	person-day	6.0	20000.0	120000.0	100.0
Weeding	person-day	20.0	20000.0	400000.0	100.0
Plant material					
Chili	kg	3.0	10000.0	30000.0	100.0
Other					
Gasoline for pumping and watering	liter	34.0	2500.0	85000.0	100.0
Total costs for maintenance of the Technology				635000.0	

NATURAL ENVIRONMENT

Average annual rainfall
☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☑ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone
☐ humid
☑ sub-humid
☐ semi-arid
☐ arid

Specifications on climate
Average annual rainfall in mm: 1102.02
The annual rainfall in 2015 is 1102.02 mm. In 2014 is 878.13 mm and in 2013 is 1393.5 mm.
Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)

Slope
☑ flat (0-2%)
☐ gentle (3-5%)
☐ moderate (6-10%)
☐ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☑ 0-100 m a.s.l.
☐ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☐ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☑ very deep (> 120 cm)

Soil texture (topsoil)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☑ medium (1-3%)
☐ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☑ good
☐ medium
☐ poor/ none

Water quality (untreated)
☐ good drinking water
☑ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☑ Yes
☐ No

Species diversity
☐ high
☑ medium
☐ low

Habitat diversity
☐ high
☑ medium
☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☐ mixed (subsistence/ commercial
☑ commercial/ market

Off-farm income
☑ less than 10% of all income
☐ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
☐ poor
☑ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☐ animal traction
☐ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☐ women
☑ men

Age
☐ children
☐ youth
☐ middle-aged
☑ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☑ 2-5 ha

Scale
☐ small-scale
☑ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

☐ individual, not titled
☑ individual, titled

Water use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor	☐ ☐ ✓	good
education	poor	☐ ☐ ✓	good
technical assistance	poor	✓ ☐ ☐	good
employment (e.g. off-farm)	poor	✓ ☐ ☐	good
markets	poor	✓ ☐ ☐	good
energy	poor	✓ ☐ ☐	good
roads and transport	poor	✓ ☐ ☐	good
drinking water and sanitation	poor	☐ ✓ ☐	good
financial services	poor	☐ ☐ ✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased	☐ ☐ ☐ ☐ ☐ ☐ ✓	increased	Due to the fact that he cultivates more crops than before on the same plot. The farmer can continuously harvest because there are long-term crops and annual crops.
crop quality	decreased	☐ ☐ ☐ ☐ ☐ ☐ ✓	increased	The benefits of this kind of agroforestry are permanent soil cover, less soil degradation, optimal light and shadow situation and microclimate (different high of plants), better organic matter maintenance (decomposition of leaves and pruning residuals), better control of pests and diseases though higher amount beneficial insect species what led finally to high crop quality.
land management	hindered	☐ ☐ ☐ ☐ ✓ ☐ ☐	simplified	Less weeding is necessary and also less pest control.
demand for irrigation water	increased	☐ ☐ ☐ ✓ ☐ ☐ ☐	decreased	The chili plants need to be watered and by this orange trees gets also enough moisture.
expenses on agricultural inputs	increased	☐ ☐ ✓ ☐ ☐ ☐ ☐	decreased	Before he planted only one crop but nowadays, there are so many varieties that the costs for inputs has increased slightly.
workload	increased	☐ ✓ ☐ ☐ ☐ ☐ ☐	decreased	Orange trees do not need much care. But the crops between the trees need more care than the mango trees that he planted before.

Socio-cultural impacts

food security/ self-sufficiency	reduced	☐ ☐ ☐ ☐ ☐ ✓ ☐	improved	He gets actually better income because before he grows only long-term crops, but now he grows short-term crops too. In consequence, the food security has been improved.

Ecological impacts

evaporation	increased	☐ ☐ ☐ ☐ ☐ ☐ ✓	decreased	The good soil cover and the shadow from the orange trees, decreased significantly the soil evaporation.
soil moisture	decreased	☐ ☐ ☐ ☐ ☐ ☐ ✓	increased	The short-term crops contribute to better soil moisture.
soil cover	reduced	☐ ☐ ☐ ☐ ☐ ✓ ☐	improved	In the past, only long-term crops as e.g. mango trees have grown on the plot. But due to the supplement short-term crops soil cover has been improved.
soil compaction	increased	☐ ☐ ☐ ☐ ✓ ☐ ☐	reduced	By the use of crop residues as green manure and cow manure the farmer got better soil structure and less soil compaction on his plot.
nutrient cycling/ recharge	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	The farmer uses only cow manure and crops residues and was able therefore to reduce chemical fertilizer.
vegetation cover	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Due to permanent crop cover all over the year.
plant diversity	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	He grows both long-term crops and short-term crops.
beneficial species (predators,	decreased	☐ ☐ ☐ ☐ ☐ ☐ ☐	increased	

earthworms, pollinators)

habitat diversity	decreased					✓			increased	Cow manure and crops residues are elements that led increase beneficial species. Animals like for example birds are attracted by the trees, and soil and microfloras and fauna has been stimulated by the intercropping system.
pest/ disease control	decreased				✓				increased	The former monocropping system attracted more pests, as it facilitated its multiplication and dispersion.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative						✓		very positive

Benefits compared with maintenance costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative					✓			very positive

Long-term benefits depend on orange yields.

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes							
Gradual climate change								
annual temperature increase	not well at all						very well	Answer: not known
annual rainfall increase	not well at all			✓			very well	
Climate change is irregular increase	not well at all						very well	Answer: not known
Climate-related extremes (disasters)								
extreme winter conditions	not well at all		✓				very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☐ 1-10%
☐ 10-50%
☑ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Even if the land is small a large variety of crops can be planted.
- Crop residue mixed with cow manure can make the soil more fertile.
- The farmer is able to generate income continuously from the short-term crops before the long-term crop provides its yield.

Strengths: compiler's or other key resource person's view

- If the farmer plants only orange trees, the time consume for maintenance will be similar to the time consume for maintenance of both, orange trees and chilies, thus, this practice saves time in crop maintenance.
- Different crops absorb different nutrients, and therefore the application of fertilizer made from cow manure and crop residue helps to maintain the soil's balance and improve its quality.
- This technique can maintain the soil's moisture and does not lead to soil compaction because the soil obtains additional fertilizer and especially organic waste.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- A drilled well cannot supply enough water in the dry season. → Reduce the amount of plants according the amount of available wate, or apply a drip irrigation system to help saving water.
- There have been some diamondback moth (worms) destroying the vegetables. → Use standard pesticides
- A lack of labor → Hire additional labor

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

REFERENCES

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Date of documentation: Sept. 8, 2017

Last update: Jan. 10, 2018

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Chantha Chhem (c.chantha228@gmail.com) - Chief of Agricultural Extension Official at District Office of Agriculture, Forestry and Fisheries, Sankae
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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_3171/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

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Intercropping of mungbean between orange trees on the mountainous area of Cambodia (Mr.Sok Pheak)

Intercropping of orange trees with mungbean in mountainous areas (Cambodia)

Intercropping

DESCRIPTION

Intercropping of mungbean between orange trees improves soil fertility and generates income before the orange trees bear fruit.

Agroforestry is a farming practice that can involve growing of a mixture of woody perennials like trees, shrubs, palms, bamboos, etc. with crops and/or animals, on the same land-management units. Agroforestry systems play an important role in ecological and economical interactions between the different land use components (Lundgren and Raintree, 1982). It represents an interface between agriculture and forestry, and encompasses mixed land-use practices. Agroforestry systems are composed of three attributes:

1. Productivity (improved tree products, yields of associated crops, reduction of cropping system inputs, and increased labor use efficiency);
2. Sustainability (beneficial effects of woody perennials);
3. Adoptability (MoE/Adaptation Fund/UNEP, 2016).

In Cambodia, mungbean grows throughout the whole year almost, depending on the moisture factor. Mungbean is short maturity crop which can be grown both in sloping upland and in lowland areas. In upland areas farmers usually plant their second crop in August and harvest it in October. Mungbean is a crop that can be grown on many soil types, but grows best on alluvial, sandy, and volcanic soils which well drained containing high levels of nutrients (incl. N, P, K, Ca, Mg) and organic matter (MAFF, 2005). Mungbean crop duration depends on the variety, with short-term, medium-term and long-term being harvested between 60-65 days, 65-75 days, and 75-80 days, respectively.

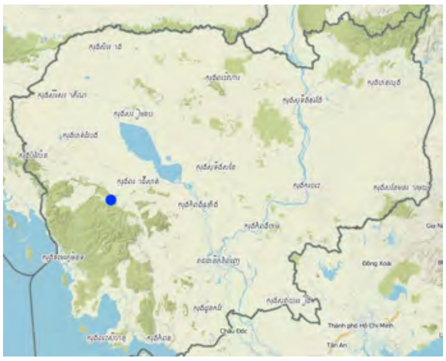
Mungbean residues can make an active contribution to improvement of soil quality through nitrogen fixation and subsequent incorporation of this nitrogen into the soil after root and nodule degeneration by Rhizobium bacteria. The incorporation of the organic root material also improves the soil structure (MAFF, 2005, Chadha, 2010, IRRI-CIMMYT Alliance, 2009). The taproot of the mungbean can penetrate the soil to a depth of 50-60 centimeters. Sometimes, some land users grow mungbean as a green manure crop specifically to improve soil quality (Tauch Ung, 2010).

Mr. Chea Sarith is one example of land user who practices intercropping of orange trees with mungbean since 2013. The main purpose is to improve soil fertility, to prevent soil erosion, and to generate income before the orange trees provide fruit. In addition, it eases the weed control. After the harvest the farmer leaves the plant residues on the soil to provide organic matter. With the objective not to harm the roots of the orange trees, he avoids tilling the soil. In general, mungbean grows twice a season depending on the rainfall distribution and soil moisture.

The average yield of direct seeded mungbean as an intercrop between orange trees is about 1,200 kg/ha (harvested 3 times per crop). If mungbean is grown as a single crop the yield is usually ranges from 1,300 to 1,400 kg/ha. The market price for mungbean grain is usually about 4,500 to 5,000 Riel/kg.

Before planting orange trees the soil requires two turns of ploughing. After first ploughing the soil should dry during 1-2 months, before it can be ploughed again by a wheel harrow. Orange trees then are planted in rows into pits of 1 m x 1 m, with a depth of 70-80 cm. The spacing between the trees, as well as between the rows is usually 6

LOCATION



Location: Phnum Kravanh of Cambodia., Ongkrong Village, Samrong Commune, Phnum Kravanh District, Pursat Province., Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 103.58329, 12.3103

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 2013

Type of introduction

☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☑ during experiments/ research
☐ through projects/ external interventions

meters. Before planting, the orange tree seedlings (bought from outside) are usually kept at the farm site for 15 to 20 days, which to allow them to adapt to the conditions of the growing environment. The farmer installed a water pipe in the underground to irrigate the fruit orchard. The nearby stream serves as water source. After the tree plantation, mungbean is sown by direct seeding on the remaining bare soil. This is done by putting 3 to 4 seeds into the seed holes (3 to 4 cm sowing depth at a plant spacing of 20 cm and a row spacing of 30 cm. After harvest the residues of the mungbean plants are squashed by machine and left to rot on the soil surface until is the next mungbean cycle starts by direct seeding.


Orange Trees (Mr. Sok Pheak)


Mungbean during maturity. (Mr. Sok Pheak)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose
☑ improve production
☑ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use
Mixed (crops/ grazing/ trees), incl. agroforestry - Agroforestry
Main products/ services: Orange and mungbean.

Water supply
☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 1
Land use before implementation of the Technology: Degraded forest, soil from termite mound.
Livestock density: n.a.

Purpose related to land degradation
☑ prevent land degradation
☐ reduce land degradation
☑ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed
soil erosion by wind - Et: loss of topsoil

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

physical soil deterioration - Pc: compaction

biological degradation - Bc: reduction of vegetation cover, Bl: loss of soil life

SLM group
- agroforestry
- improved ground/ vegetation cover

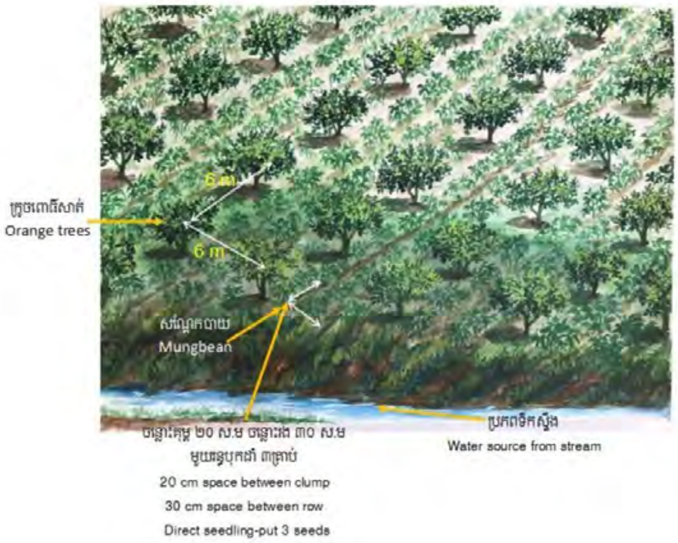
SLM measures
agronomic measures - A1: Vegetation/ soil cover, A3: Soil surface treatment

structural measures - S7: Water harvesting/ supply/ irrigation equipment

TECHNICAL DRAWING

Technical specifications

The area of implementing this technology is 4 hectares with 1096 orange trees. The pit of planting orange trees is 1m x 1m, with a depth of 70-80 cm. The spacing between trees and between rows is usually 6 meters to get enough sunlight. The mungbean is planted by direct seedling by inserting 3 to 4 seeds per hole (the hole is 3-4 cm in depth). The spacing between the holes is 20 cm and the row spacing is 30 cm. The farmer of this farm also installed an irrigation system by setting up a pipe under the ground.



Author: Mr. Khoun Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **4 hectares**)
- Currency used for cost calculation: **KHR (Riel)**
- Exchange rate (to USD): 1 USD = 4000.0 KHR (Riel)
- Average wage cost of hired labour per day: 20000

Most important factors affecting the costs

The establishment of an orange tree orachard requires a lot of money.

Establishment activities

1. Clear degraded forest (Timing/ frequency: January)
2. Clear the termite mound to flatten the area (Timing/ frequency: Dry season)
3. Drying the soil by sunlight (Timing/ frequency: Dry season)
4. Buy orange trees and adapt them to the condition of the area (Timing/ frequency: Dry season)
5. Planting orange trees (Timing/ frequency: August)

Establishment inputs and costs (per 4 hectares)

Specify input	Unit	Quantity	Costs per Unit (KHR (Riel))	Total costs per input (KHR (Riel))	% of costs borne by land users
Labour					
Clear the degraded forest soil	Person-day	80.0	2000.0	160000.0	100.0
Collect the residue of forest and then burn	Person-day	60.0	20000.0	1200000.0	100.0
Clear 40 termite mounds in 4 hectares	Person-day	48.0	20000.0	960000.0	100.0
Hire labor to carry the soil of termite mound to put in the hole of orange tree for planting	Person-day	180.0	20000.0	3600000.0	100.0
Equipment					
Grass cutting marchine	piece	2.0	1200000.0	2400000.0	100.0
Two wheel tractor	piece	1.0	12000000.0	12000000.0	100.0
Plant material					
Orange seedlings	seedling	1026.0	6000.0	6156000.0	100.0
Construction material					
Pumping machine	piece	1.0	1200000.0	1200000.0	100.0
Irrigation system such as big tube, small tube etc	set	1.0	8000000.0	8000000.0	100.0
Other					
Planting orange trees	Person-day	51.0	20000.0	1020000.0	100.0
Pesticide sprayer machine	piece	3.0	600000.0	1800000.0	100.0
Spraying pesticide hand pump sprayer	piece	1.0	280000.0	280000.0	100.0
Total costs for establishment of the Technology				**38776000.0**	

Maintenance activities

1. Watering during dry season in the first year of planting orange trees (Timing/ frequency: Two times per day during dry season)
2. Spraying pesticides when there is present of insects on orange trees (Timing/ frequency: Spray once time per season)
3. Pruning some branches of orange trees (Timing/ frequency: When the orange trees 2 years (One year cut some branches once time))
4. Apply organic fertilizer for the orange trees (Timing/ frequency: When the orange trees are 4 years)
5. Spray against weeds (Timing/ frequency: Spray once time per half month.)
6. Spray pesticides on mungbean plants (Timing/ frequency: When mungbean flowering)
7. Direct seeding of mungbean (Timing/ frequency: August)

Maintenance inputs and costs (per 4 hectares)

Specify input	Unit	Quantity	Costs per Unit (KHR (Riel))	Total costs per input (KHR (Riel))	% of costs borne by land users
Labour					
Watering the orange trees	Person-day	11.0	20000.0	220000.0	100.0
Pruning some branches of orange trees	Person-day	100.0	20000.0	2000000.0	100.0
Hire labor to spray pesticides	Person-day	8.0	20000.0	160000.0	100.0
Hire labor to harvest mungbean when mature	Person-day	120.0	20000.0	2400000.0	100.0
Plant material					
Mungbean seed (1 hectare need 25 kg of mungbean) seeds	hectare	4.0	312500.0	1250000.0	100.0
Fertilizers and biocides					
Pesticides for orange trees	bottle	4.0	40000.0	160000.0	100.0
Chemicals for improving of stem of mungbean	package	60.0	1500.0	90000.0	100.0
Pesticide to kill worms on mungbean	bottle	2.0	40000.0	80000.0	100.0
Other					
Direct seeding of mungbean	Person-day	56.0	20000.0	1120000.0	100.0
Total costs for maintenance of the Technology				7480000.0	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate

Average annual rainfall in mm: 1225.7

In 2015 the annual rainfall is 1225.7 mm, in 2014 is 1128.1 and in 2013 is 1316 mm.

Name of the meteorological station: Ministry of water resources and meteorology, 2015

Slope
- ☐ flat (0-2%)
- ☑ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☐ plateau/plains
- ☐ ridges
- ☑ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☐ 0-100 m a.s.l.
- ☑ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☑ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☐ very deep (> 120 cm)

Soil texture (topsoil)
- ☑ coarse/ light (sandy)
- ☐ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☑ coarse/ light (sandy)
- ☐ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Topsoil organic matter content
- ☐ high (>3%)
- ☑ medium (1-3%)
- ☐ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☑ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☑ good
- ☐ medium
- ☐ poor/ none

Water quality (untreated)
- ☑ good drinking water
- ☐ poor drinking water (treatment required)
- ☐ for agricultural use only (irrigation)
- ☐ unusable

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☐ Yes
- ☑ No

Species diversity
- ☐ high
- ☑ medium
- ☐ low

Habitat diversity
- ☐ high
- ☑ medium
- ☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☐ mixed (subsistence/ commercial
- ☑ commercial/ market

Off-farm income
- ☑ less than 10% of all income
- ☐ 10-50% of all income
- ☐ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☐ poor
- ☑ average
- ☐ rich
- ☐ very rich

Level of mechanization
- ☑ manual work
- ☐ animal traction
- ☑ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative
- ☐ employee (company, government)

Gender
- ☐ women
- ☑ men

Age
- ☐ children
- ☐ youth
- ☑ middle-aged
- ☐ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☑ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☐ small-scale
☑ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor			✓	good
education	poor			✓	good
technical assistance	poor			✓	good
employment (e.g. off-farm)	poor		✓		good
markets	poor			✓	good
energy	poor			✓	good
roads and transport	poor			✓	good
drinking water and sanitation	poor			✓	good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased						✓		increased	The soil fertility was improved, so that the crop production increased steadily. In addition, the farmer now doesn't grow only orange trees, but he also grows mungbean.
crop quality	decreased						✓		increased	The residues of mungbean contain many nutrients, which is suitable for getting good crop quality.
risk of production failure	increased						✓		decreased	As the farmer plants more than one crop on the plot now, it reduces the production failure. This means that farmer get income from mungbeans before the orange trees provide fruits. The better weed control also reduces insects, which could be harmful to the crop.
product diversity	decreased						✓		increased	There are mungbean and orange trees, now.
expenses on agricultural inputs	increased						✓		decreased	Reduced chemical fertilizers on orange trees and mungbean, because after harvesting mungbean residues are kept on the soil which is very good green manure for soil.
farm income	decreased							✓	increased	The farm income increases considerably due the intercropping system, as both mungbean and orange trees provide yield. In addition, mungbeans provide yield two times per year. Last but not least , mungbean play a key role as green manure which reduces the input of chemical fertilizers and therefore cost.
workload	increased				✓				decreased	The mungbean and orange tree cultivation does not consume much of labor force because he doesn't have to spend a lot of time for weeding (as instead of weed mungbeans cover the soil now). On the other hand, the farmer mentioned that the orange plantation is time consuming at the beginning, when the orange trees has to be planted. As well the mungbean need more time at the moment when the plot has to be prepared for first direct seedling. But the technology as a whole entails not a lot of maintenance workload as he uses machinery such as pesticide sprayer machine and mungbean squash machine to facilitate the labor.

Socio-cultural impacts

food security/ self-sufficiency	reduced							✓	improved	The diversification of the crops (oranges and mungbean) has considerably raised the income and therefore strongly prevent food insecurity situations.
health situation	worsened						✓		improved	The reduction of chemical fertilizer and pesticides provides safer products that improves the health

situation. In addition, mungbean and orange fruit deliver many nutrition benefits to human health.

community institutions	weakened						✓		strengthened	He has joined the orange trees community to sell the orange fruits. Many researches are convinced of his success and the tastiness of his oranges; as for example researchers from the District Office of Agriculture, Forestry and Fisheries, Phnum Kravanh, Provincial Department of Agriculture, Forestry and Fisheries, Pursat etc."
SLM/ land degradation knowledge	reduced							✓	improved	By doing the farmer learned that degraded soil can be rehabilitated by the mean of mungbean residues acting as green manure. And from the moment the soil is rehabilitated he can see that this green manure prevents soil degradation at high degree.
Ecological impacts										
soil moisture	decreased						✓		increased	Mungbean and orange trees keep the soil moisture, prevent the evaporation to the atmosphere.
soil cover	reduced						✓		improved	Orange trees and mainly the mungbean intercrop cover the soil almost entirely all year around.
soil compaction	increased						✓		reduced	The residue of mungbean reduce soil compact by improving the soil structure through providing organic matter to the soil. The increased amount of soil organisms make the sol less compact.
soil organic matter/ below ground C	decreased							✓	increased	The residues of mungbean left on the soil after harvesting are transformed to organic matter by the process of decay and therefore contribute essentially to increased soil organic matter.
vegetation cover	decreased						✓		increased	Orange trees and mungbeans are the vegetation cover to avoid bare land, so the sunlight will not come directly to the the soil.
plant diversity	decreased						✓		increased	There is more than one crop (orange trees and mungbean).
beneficial species (predators, earthworms, pollinators)	decreased						✓		increased	Now, the soil is somewhat richer in termites, ants, earthworms, crickets ect.
habitat diversity	decreased						✓		increased	Orange trees and mungbean cultivation promote soil organisms in the habitat.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs									
Short-term returns	very negative						✓		very positive
Long-term returns	very negative						✓		very positive
Benefits compared with maintenance costs									
Short-term returns	very negative						✓		very positive
Long-term returns	very negative							✓	very positive

When the orange trees grow bigger, it will provide very high income.

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	**How the Technology copes with these changes/extremes**							
Gradual climate change								
annual temperature increase	not well at all				✓		very well	
seasonal temperature increase	not well at all			✓			very well	Season: wet/ rainy season
seasonal temperature increase	not well at all				✓		very well	Season: dry season
annual rainfall increase	not well at all			✓			very well	
seasonal rainfall increase	not well at all			✓			very well	Season: wet/ rainy season

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ single cases/ experimental
☑ 1-10%
☐ 10-50%
☐ more than 50%

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Has the Technology been modified recently to adapt to changing conditions?
☐ Yes
☑ No

To which changing conditions?
☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Get income from the mungbean before orange trees provide fruit as a potential source of income.
- The residues from the mungbean plants help to improve soil fertility.
- The potential market of orange tree fruits is good, with traders buying directly from producers at the farm.

Strengths: compiler's or other key resource person's view

- Residues of mungbean improve soil fertility, reduce soil degradation and help rehabilitate the degraded land.
- In the initial 3 to 4 years of growth of orange trees it is important to grow short term crops like mungbean to provide an income source.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Orange trees require a lot of water. → Grow near a water source such as a stream or river, or dig ponds to hold water. Land users need to consider a potential water source.
- When the soils become saturated due to excessive rain, the mungbean plant roots can degenerate and result in low grain yields and low grain price (due to poor grain quality). → There is little that farmers can do to improve the performance of the mung bean crop in conditions of soil moisture saturation.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- As the orange trees grow bigger there is reduced opportunity for intercropping with mungbean. → Grow intercrops that do not require much sunlight, such as ginger or galanga

REFERENCES

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Date of documentation: Aug. 22, 2017

Last update: Jan. 10, 2018

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_3146/

Linked SLM data
n.a.

Documentation was faciliated by
Institution

- Royal University of Agriculture (RUA) - Cambodia

Project

- Scaling-up SLM practices by smallholder farmers (IFAD)

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Eggplants between Lemon trees (Mr. Kim Soben)

Eggplant cultivation technique between lemon trees (Cambodia)

Mixed cropping

DESCRIPTION

Eggplant cultivation between lemon trees using restroom and crop residues as a source of soil nutrients instead of being reliant on the use of chemical fertilizers.

Growing short-term crops or vegetables like eggplants and other crops between long-term crops belongs to the category of intercropping system. In case the farmer plants trees like lemon trees as long-term crop it can further be declared as agroforestry system. One important reason why farmers grow both, long-term and short-term crops on the same plot is to optimize the use of land resources. Another reason is that the short-term crops offer the opportunity to generate income to the farmers long before the long-term crop is productive.

These were also among the main reasons why Mr. Sokhom Oem from Svay sa village, Khnach romeas commune, Bavel district, Battambang province (the north-western province of Cambodia). He changed from mono-cropping to the intercropping system in 2016. His farm is connected to very deep alluvial soils (pH=5) with high topsoil organic matter and medium soil texture. The average annual rainfall in the region is 1100 mm. On a flat plot of 325.5 square meters (18.3 x 45 meters), he planted 10 lines of lemon trees (4 lemon trees per line). The space between each lemon tree is 4.5 x 4.5 meters. On his first year in December, after plowing and drying the soil, he planted eggplants at a distance of 80 to 100 cm on 40 rows between the lemon trees (16 plants per row = 640 plants). The reason why many farmers potentially prefer eggplants as an intercrop is that it can be grown as a yearlong crop that provides an initial fruit harvest only after one month of planting. After first harvest they continue to bear fruit during the whole year long. A fact that is very appreciated by the farmer, as this kind of plant does not require lots of work. Nevertheless, the productivity of the intercropped eggplant depends on its maintenance. Old leaves need to be removed when the plant has few flowers (General Directorate of Agriculture, 2012). After the eggplant cultivation the farmer can change to other intercrop vegetable if he likes. Lemon trees, on the other hand, can take up to three years before they produce fruit for harvest, after which they can be harvested continuously during 8 to 10 years. Sometimes trees can provide fruit during the whole year, but their productivity depends on sufficient water supply during the period from flowering to harvest. All in all, while waiting for full lemon yield the eggplants are an early and secure source of income. A further advantage to be mentioned is that eggplants improve the soil cover that protects from weed growing and in consequence eases the land management.

Besides the optimal use of the land, this technology also maintains and improves soil quality through the use of toilet residues. Only well decomposed liquid toilet waste (without a strong smell) is used in the form of a mixture of urine and feces which is drained from the septic tank. The application of this organic waste is based on the application of between 300-400 mm per lemon tree, after which normal watering is practiced. This liquid toilet waste is applied again when an intercrop like eggplants are producing less harvestable fruit. The intercrop plant residues are also kept as soil cover between the lemon trees, to provide more organic instead of using chemical fertilizer. The intercrop residues also help maintain the soil moisture content.

At some time after the initial adoption of this intercropping technology including the use

LOCATION

Location: Svay Sa village, Khnach Romeas commune, Bavel district, Battambang province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 102.97686, 13.27043

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 2016; less than 10 years ago (recently)

Type of introduction

☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☐ through projects/ external interventions

of organic residues, land users understand the need for maintenance rather than anticipating ongoing long-term benefits after the immediate benefits. For example, the watering of the intercropped eggplants and of the lemon trees needs to be maintained in order to maintain their productivity. It is noted that farmers are able to achieve better and more sustainable incomes from the intercropping when compared with their previous practice of single cropping with corn or in the case of this study site sugar cane.


Starting production (Mr. Kim Soben)


Farmer is checking his crops (Mr. Kim Soben)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose
☑ improve production
☑ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use
Mixed (crops/ grazing/ trees), incl. agroforestry - Agroforestry
Main products/ services: Eggplants and lemon trees

Water supply
☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 1
Land use before implementation of the Technology: Before the land was cultivated by sugar cane (mono-cropping)
Livestock density: n.a.

Purpose related to land degradation
☑ prevent land degradation
☐ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed
chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion

biological degradation - Bq: quantity/ biomass decline

water degradation - Ha: aridification

SLM group
- agroforestry
- improved ground/ vegetation cover
- integrated soil fertility management

SLM measures
agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility

vegetative measures -

TECHNICAL DRAWING

Technical specifications

This technology is applied on 823,5 square meters of land (18,3 meters x 45 meters) which contains 10 lines of lemon trees with 4 trees per line. The space between each lemon tree is 4,5 x 4,5 meters. For planting the trees the pit size is 15 square cm in area and 20 cm in depth. The normal space between the eggplant is 80 to 100 cm. On 40 lines - each line contains 16 plants - 640 eggplants are planted. Custard apples and bananas can also be grown in the surrounding area. On the other hand, this technology also maintains and improves soil quality through the use of toilet residues. Only well decomposed liquid toilet waste (without a strong smell) is used in the form of a mixture of urine and feces which is drained from the septic tank.

Author: Dr. So Than and Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **823,5 square meters**)
- Currency used for cost calculation: **KHR (Riel)**
- Exchange rate (to USD): 1 USD = 4000.0 KHR (Riel)
- Average wage cost of hired labour per day: 20000 Riel

Most important factors affecting the costs

The organical pesticide application to the eggplants is most cost-relevant.

Establishment activities

1. Plow and sundry the soil (Timing/ frequency: October)
2. Lemon trees propagation (marcotting) (Timing/ frequency: October)
3. Lemon tree plantation (Timing/ frequency: November)

Establishment inputs and costs (per 823,5 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR (Riel))	Total costs per input (KHR (Riel))	% of costs borne by land users
Labour					
Plow and sundry the soil	person-day	6.0	20000.0	120000.0	100.0
Lemon tree propagation (marcotting)	person-day	1.0	20000.0	20000.0	100.0
Dig the hole for lemon tree planting	person-day	1.0	20000.0	20000.0	100.0
Equipment					
Drilled well (motor pump included)	set	1.0	750000.0	750000.0	100.0
Hoe	piece	2.0	20000.0	40000.0	100.0
Spade	piece	1.0	15000.0	15000.0	100.0
Two handle basket (to carry the soil)	pair	1.0	15000.0	15000.0	100.0
Plant material					
Lemon tree	tree	36.0	5000.0	180000.0	100.0
Eggplant seeds	package	2.0	50000.0	100000.0	100.0
Construction material					
Watering tank	pair	2.0	25000.0	50000.0	100.0
Pipe	meter	40.0	12000.0	480000.0	100.0
Total costs for establishment of the Technology				**1790000.0**	

Maintenance activities

1. Eggplant nursery (Timing/ frequency: November)
2. Plow and sundry the soil (Timing/ frequency: December)
3. Eggplant plantation (Timing/ frequency: December)
4. Watering lemon trees (Timing/ frequency: Watering only in dry season)
5. Spraying botanical pesticide (Timing/ frequency: Applied when insects appeared)
6. Application of restroom residues (on ground of lemon trees) (Timing/ frequency: 2 times/ year)
7. Watering the crops (Timing/ frequency: Watering a times/3 days to 7 days)
8. Application of restroom residue (eggplants) (Timing/ frequency: When fruit is reduced or leaves appear unusual signs as yellow leaves)
9. Application of pesticide to the eggplants (Timing/ frequency: 2 times/ week)

Maintenance inputs and costs (per 823,5 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR (Riel))	Total costs per input (KHR (Riel))	% of costs borne by land users
Labour					
Eggplant nursery and plantation	person-day	2.5	20000.0	50000.0	100.0
Watering lemon trees	person-day	26.0	20000.0	520000.0	100.0
Pesticide spraying	person-day	78.75	20000.0	1575000.0	100.0
Application of fertilizer	person-day	3.0	20000.0	60000.0	100.0
Plant material					
Eggplant seeds	package	2.0	50000.0	100000.0	100.0
Fertilizers and biocides					
Pesticide (worm)	bottle	2.0	25000.0	50000.0	100.0
Pesticide (vegetable louse)	bottle	2.0	25000.0	50000.0	100.0
Total costs for maintenance of the Technology				**2405000.0**	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate
Average annual rainfall in mm: 1102.02
The annual rainfall in 2015 is 1102.02 mm. In 2014 is 878.13 mm and in 2013 is 1393 mm.
Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)

Slope
- ☑ flat (0-2%)
- ☐ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☑ plateau/plains
- ☐ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☑ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☐ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☑ very deep (> 120 cm)

Soil texture (topsoil)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Topsoil organic matter content
- ☑ high (>3%)
- ☐ medium (1-3%)
- ☐ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☑ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☐ good
- ☐ medium
- ☑ poor/ none

Water quality (untreated)
- ☑ good drinking water
- ☐ poor drinking water (treatment required)
- ☐ for agricultural use only (irrigation)
- ☐ unusable

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☐ Yes
- ☑ No

Species diversity
- ☐ high
- ☐ medium
- ☑ low

Habitat diversity
- ☐ high
- ☐ medium
- ☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☐ mixed (subsistence/ commercial
- ☑ commercial/ market

Off-farm income
- ☐ less than 10% of all income
- ☐ 10-50% of all income
- ☑ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☐ poor
- ☑ average
- ☐ rich
- ☐ very rich

Level of mechanization
- ☑ manual work
- ☐ animal traction
- ☐ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative
- ☐ employee (company, government)

Gender
- ☐ women
- ☑ men

Age
- ☐ children
- ☐ youth
- ☑ middle-aged
- ☐ elderly

Area used per household
- ☐ < 0.5 ha

Scale
- ☐ small-scale

Land ownership
- ☐ state

Land use rights
- ☐ open access (unorganized)

☐ 0.5-1 ha
☑ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

☑ medium-scale
☐ large-scale

☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

☐ communal (organized)
☐ leased
☑ individual

Water use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor	☐ ☐ ☑	good
education	poor	☐ ☐ ☑	good
technical assistance	poor	☑ ☐ ☐	good
employment (e.g. off-farm)	poor	☑ ☐ ☐	good
markets	poor	☐ ☑ ☐	good
energy	poor	☑ ☐ ☐	good
roads and transport	poor	☐ ☐ ☑	good
drinking water and sanitation	poor	☐ ☐ ☑	good
financial services	poor	☐ ☐ ☑	good

IMPACTS

Socio-economic impacts

Crop production	decreased	☐ ☐ ☐ ☐ ☐ ☑ ☐	increased	Crop production increased because previously he planted only one crop, but now he plants other crops between long term crops in addition.
crop quality	decreased	☐ ☐ ☐ ☐ ☐ ☑ ☐	increased	The quality of the crop is better because he uses waste from the restroom with crop residues. This has replaced the chemical fertilizer.
risk of production failure	increased	☐ ☐ ☐ ☐ ☐ ☑ ☐	decreased	He grows more than one crop, so if there is any problem with one crop, he can get income from the other crop.
product diversity	decreased	☐ ☐ ☐ ☐ ☐ ☑ ☐	increased	Now he cultivates more different crops than before.
production area (new land under cultivation/ use)	decreased	☐ ☐ ☐ ☐ ☑ ☐ ☐	increased	The production area increased slightly in the sense that he optimized the use of the existing farm area.
land management	hindered	☐ ☐ ☐ ☐ ☐ ☑ ☐	simplified	He cultivates vegetables with long-term crops using toilet residues.
expenses on agricultural inputs	increased	☐ ☐ ☐ ☐ ☐ ☑ ☐	decreased	Before he used only chemical fertilizer.
farm income	decreased	☐ ☐ ☐ ☐ ☐ ☑ ☐	increased	Between the lemon trees, a large amount of crops (vegetable) has been cultivated, that generates better farm income.
diversity of income sources	decreased	☐ ☐ ☐ ☐ ☐ ☐ ☑	increased	Before only the lemon trees produced fruits, now he can get income from the crops between them.
economic disparities	increased	☐ ☐ ☐ ☐ ☐ ☑ ☐	decreased	The income of the farmer has increased and therefore his economic situation has been improved.
workload	increased	☐ ☐ ☐ ☐ ☑ ☐ ☐	decreased	He has more work to do, but it is less difficult than before.

Socio-cultural impacts

food security/ self-sufficiency	reduced	☐ ☐ ☐ ☐ ☐ ☑ ☐	improved	Now he gets daily income from the crops.
health situation	worsened	☐ ☐ ☐ ☐ ☐ ☑ ☐	improved	Better than at previous time because instead of using chemical fertilizer, now he uses fertilizer from decomposed toilet waste which is mixed with crops residues.
SLM/ land degradation knowledge	reduced	☐ ☐ ☐ ☐ ☐ ☑ ☐	improved	During the first year of application he learned constantly how to better handle and maintain the eggplants cultivation.

Ecological impacts

evaporation	increased	☐ ☐ ☐ ☐ ☐ ☐ ☑	decreased	The land is now covered permanentely with plants what has reduced the evaporation much.
soil moisture	decreased	☐ ☐ ☐ ☐ ☐ ☑ ☐	increased	Soil moisture is better, due to the permanent soil

				cover by crops (shadow of the leaves).
soil cover	reduced	☐ ☐ ☐ ☐ ☐ ✓ ☐	improved	Soil cover is increased by the regular crop production between the citrus trees.
soil crusting/ sealing	increased	☐ ☐ ☐ ☐ ☐ ✓ ☐	reduced	The application of decomposed toilet waste and eggplant residues on the topsoil reduced soil sealing substantially.
soil compaction	increased	☐ ☐ ☐ ☐ ☐ ✓ ☐	reduced	Soil compaction has been reduced due to using waste from the and crops residue instead of chemical fertilizers.
soil organic matter/ below ground C	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Soil organic matter is increased due to the use of waste from septic tank and other crop residues.
vegetation cover	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	There is continoued cropping after harvest.
plant diversity	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Crop types are changed regularly.
invasive alien species	increased	☐ ☐ ☐ ☐ ✓ ☐ ☐	reduced	Because of better weed control due to better plant cover by crops, the invasive alien species were slightly reduced.
beneficial species (predators, earthworms, pollinators)	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	There are many earthworms determined after the application of toilet residue instead of chemical fertilizer.
pest/ disease control	decreased	☐ ☐ ☐ ✓ ☐ ☐ ☐	increased	On the one hand eggplants need a lot of pest and disease control, as they are sensitive to pest infestation. On the other the smell of the lemon trees might hinder the invasion of particular harmful organisms. The trees also attract birds that lives from insects.
micro-climate	worsened	☐ ☐ ☐ ☐ ☐ ✓ ☐	improved	The shadow of the trees, the different height of the plants, and the higher density of plants surrounding the plot (banana plants) influenced the micro-climate to the better (windbreak, balanced heat).

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐ ☐ ☐ ☐ ☐ ✓ ☐	very positive
Long-term returns	very negative	☐ ☐ ☐ ☐ ☐ ✓ ☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐ ☐ ☐ ☐ ☐ ✓ ☐	very positive
Long-term returns	very negative	☐ ☐ ☐ ☐ ☐ ✓ ☐	very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes			
Gradual climate change				
annual temperature increase	not well at all	☐ ☐ ☐ ✓ ☐	very well	
seasonal rainfall increase	not well at all	☐ ☐ ☐ ✓ ☐	very well	Season: wet/ rainy season
Climate-related extremes (disasters)				
drought	not well at all	☐ ☐ ☐ ☐ ✓	very well	
epidemic diseases	not well at all	☐ ☐ ✓ ☐ ☐	very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☑ single cases/ experimental
☐ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Continued profitability of the land from the diversification of crops being grown.
- It is easy to take care of the crops and the lemon trees also benefit from the labour input from watering the eggplants, as the water applied also helps to meet the needs of the lemon trees.
- The technology is also adaptive to a strong sunlight and heat.

Strengths: compiler’s or other key resource person’s view

- Improves the soil nutrient level and availability based on the crop rotation and the use of restroom residues.
- Reduces the cost of chemical fertilizers and other inputs.
- Maintains soil moisture and reduces labor input required for watering and/or weeding.
- The use of cover crops reduces potential weed competition.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Some problems with disease and insects → Application of appropriate and technically recommended pesticide.
- Lack of natural pesticide techniques for prevention and control insects. → Seek support in the form of instructions and/or short-term training.

Weaknesses/ disadvantages/ risks: compiler’s or other key resource person’s view → how to overcome

REFERENCES

Compiler
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Date of documentation: Aug. 28, 2017

Last update: Jan. 31, 2018

Resource persons
Oem Sokhom (N/A) - land user
Siv Dara Phusar (N/A) - Agricultural Extension Official at District Office of Agriculture, Forestry and Fisheries, Thma Koul
Chheam Chantha (N/A) - Chief of Agricultural Extension Official at District Office of Agriculture, Forestry and Fisheries, Sankae
Mout Larm (N/A) - Agronomy Official at District Office of Agriculture, Forestry and Fisheries, Bavel

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_3153/

Linked SLM data
n.a.

Documentation was faciliated by
Institution

- Royal University of Agriculture (RUA) - Cambodia

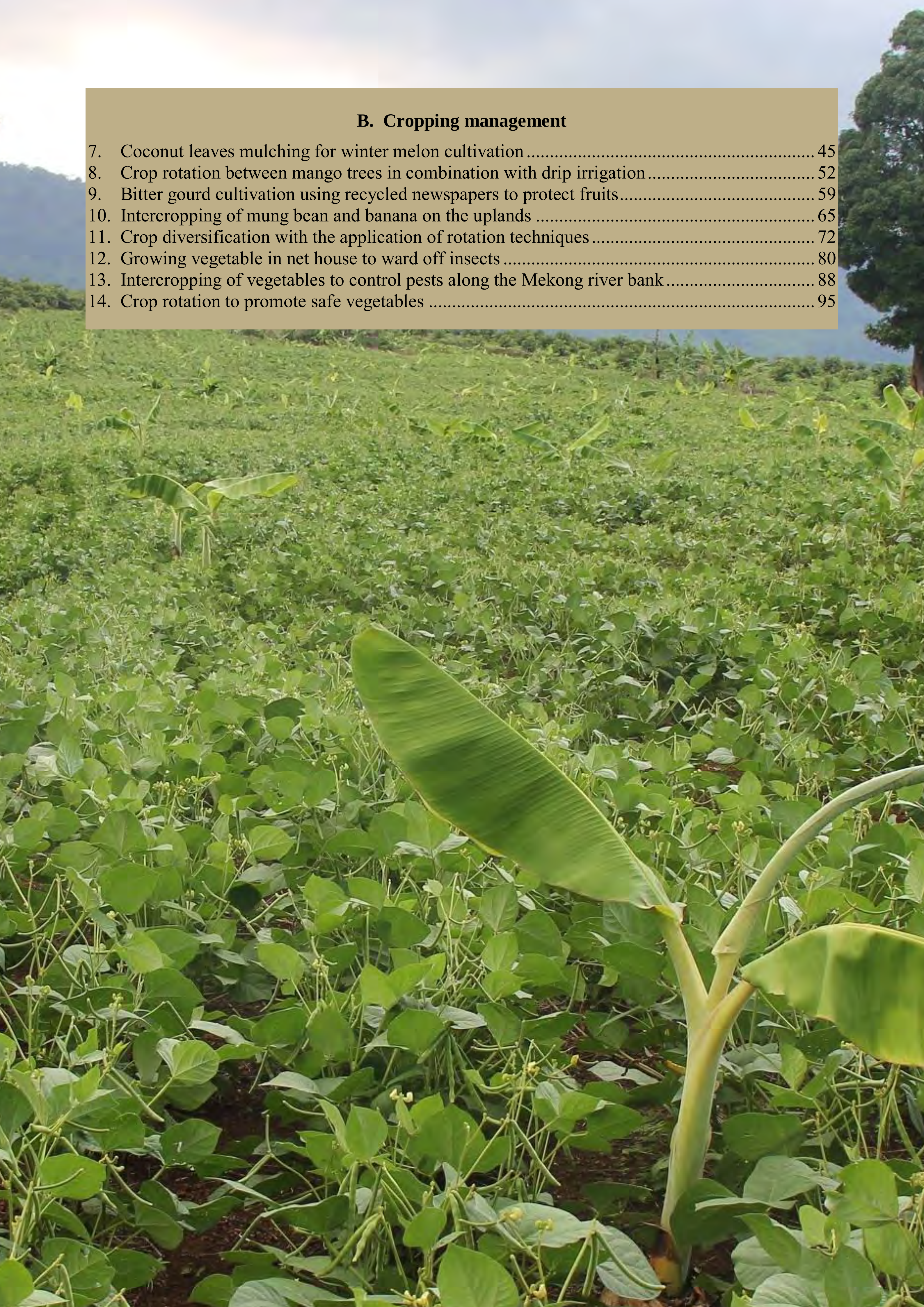
Project

- Scaling-up SLM practices by smallholder farmers (IFAD)

Links to relevant information which is available online

- General Directorate of Agriculture (2012) Vegetable techniques. (In Khmer): Retrieved on Aug 2017 from https://drive.google.com/file/d/0B41jxuufJz2-Y1c1bHpNb2ZpMm8/view
- My Agriculture Information Bank (2015) Inter Cropping and Its Advantages. My Agriculture Information Bank. Retrieved on July 25 2017 from : http://www.agriinfo.in/?page=topic&superid=1&topicid=492

B. Cropping management



Use of coconut leaves mulch covering the soil of winter melon plantation (Ms. Chea Navin)

Coconut leaves mulching for winter melon cultivation (Cambodia)

DESCRIPTION

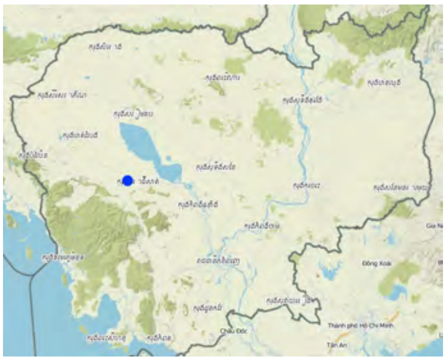
The use of coconut leaves mulch for winter melon cultivation helps to conserve soil moisture, reduces evaporation, reduces weeds, saves water, preserves the soil from erosion, and increases crop productivity.

Coconut leaves mulching is the process of covering the soil around plant root area using green/ dry coconut leaves to help keep the soil moisture longer and reduce evaporation and temperatures, especially during the dry season. Beside this, the use of coconut leaves mulch for covering rows of winter melons helps to prevent soil erosion, improves soil fertility, reduces weed growth, and increases soil fertility following the decomposition of the plant residues. The soils best suited to winter melon cultivation are loamy and sandy loam soils with a soil pH of between 5.0 and 6.3 and soils along the low-land areas. If the pH soil is lower than 5.0, the melon growth is not good and may accelerate the ripening of the fruit before the appropriate time, with the fruit plants sometimes dying due to lack of nutrients (TSTD, 2012). The roots of the winter melon are able to grow in soil with a depth of between 65 and 100 cm, particularly sandy soils. This crop is not suitable for cultivation in areas which are wind prone because of increased moisture loss through plant evapotranspiration. Such areas are also sometimes prone to high temperatures which are also unsuitable for winter melon.

The implementation area for this study was 280 squares meters, with a row height of 20-30 centimeters, a row width of 1 meter, row length of 40 meters, and row spacing of 1.5 meters. There were a total of 8 planted rows, with 40 melon stems being planted into each row. The crop stems and the intercrop space between the rows is covered with coconut leaves by laying the leaves along the slopes of the melon crop, with 5 or 6 coconut leaves as mulch along the two sides of the crop. In order to save time and water, farmers used drip irrigation using a pipe irrigation system that could provide water at a rate of about 6 liters per house, twice daily (in the morning and evening). Irrigation was provided over 20 minute periods at a rate of 100 ml per minute (although this was reduced during the rainy season). The watering technique is not required to fill the basal area of the stem of growing winter melon plants. Water is generally not provided at noon or late evening as watering at this time can cause problems, such as rotting of roots. If the soil around the stem becomes dry, more water should be applied at short notice without waiting for the soil to dry out. This is particularly important in the period immediately after planting of the seedlings, when water and nutrients are important for initial plant growth. Also, during the flowering and fruiting phases of melon plant growth, water needs have to be closely monitored. As the soil had previously been used for sugarcane cropping, the nutrient status of the soil was low, so farmers have improved the soil nutrient status by adding some organic fertilizer (cow manure) and some chemical fertilizers in an appropriate manner. In addition, some pesticides have been used as well.

In general, the advantage of this technique is the low cost materials which are locally available, such as coconut leaves, and materials which can be purchased in the local market, such as drip pipe, black plastic string, etc. However, the important aspects of the adoption of this technique, besides improving soil quality and maintaining a stable environment, is that it provides practical and potential economic benefits to farmers of about 800,000 (US$ 200) Riel per season.

LOCATION



Location: Chamkar Ou village, Trapeang chorng commune, Bakan district, Pursat province, Cambodia

No. of Technology sites analysed: 10-100 sites

Geo-reference of selected sites

- 103.79317, 12.54991

Spread of the Technology: evenly spread over an area

Date of implementation: 2013

Type of introduction

☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☑ through projects/ external interventions


Drying field after harvest of paddy rice and before planting of winter melon (Ms. Chea Navin)


View of coconut leaves used as mulch (Ms.Chea Navin)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☐ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☑ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use

Cropland - Annual cropping
Main crops (cash and food crops): Winter melon

Water supply

☐ rainfed
☐ mixed rainfed-irrigated
☑ full irrigation

Number of growing seasons per year: 3
Land use before implementation of the Technology: From 1992 to 2012 farmers were growing sugarcane
Livestock density: n.a.

Purpose related to land degradation

☑ prevent land degradation
☐ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

biological degradation - Bl: loss of soil life

water degradation - Ha: aridification

SLM group

- improved ground/ vegetation cover
- ground water management

SLM measures

agronomic measures - A2: Organic matter/ soil fertility

TECHNICAL DRAWING

Technical specifications

The implementation area of this technology is 280 square meters. The technique used for the winter melon planting area was 1 meter in width and 40 meter in length with using pipe irrigation. The farmers used an interrow spacing of 1.5 m and there are 8 rows in total. The topography of the area is flat (0-2%) with the soil being a loamy and sandy soil. The establishment activities are working for the seedling preparation, the installment of the irrigation system, the building of the pole support, the seedling transplantation, the out planting of the winter melon seedlings including the cover by coconut leaves. Cow manure, rice husks and coconut coir were used as organic nutrient sources and improving the soil organic status for maintaining a stable environment.

Author: Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **280 squre meters**; conversion factor to one hectare: **1 ha = 10000 square meters**)
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 25000 Riel

Most important factors affecting the costs

• Fixing the irrigation pipes is 20000 Riel for repair service per time. • Buying the black string for building pole support, which is 37600 Riel per time.

Establishment activities

1. Drying soil in the field (Timing/ frequency: After harvest of crops)
2. Create rows by hilling up soil (Timing/ frequency: Before onset of rains)
3. Installation of the irrigation system (Timing/ frequency: before outplanting of the winter melon)
4. Digging the hole (Timing/ frequency: 2 days before transplanting)
5. Outplanting of the winter melon seedlings including the cover by coconut leaves (Timing/ frequency: 1 day of outplanting)
6. Building the pole of support (Timing/ frequency: 3 days after transplanting)
7. Seedling transplantation (Timing/ frequency: Before onset of rains)

Establishment inputs and costs (per 280 squre meters)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Seedling preparation	person-day	1.0	25000.0	25000.0	100.0
Soil preparation	person-day	5.0	30000.0	150000.0	100.0
Building of the pole support	person-day	2.0	25000.0	50000.0	100.0
Installment of the irrigation system	pieces	2.5	27500.0	68750.0	100.0
Equipment					
Hoe	set	2.0	7000.0	14000.0	100.0
Scissors	set	5.0	2500.0	12500.0	100.0
Hacksaw	set	1.0	12000.0	12000.0	100.0
Axe	set	1.0	12000.0	12000.0	100.0
Watering can	pair	2.0	25000.0	50000.0	100.0
Floral hoe	set	3.0	15000.0	45000.0	100.0
Fertilizers and biocides					
Pesticide	bottle	2.0	2500.0	5000.0	100.0
DAP	bottle	2.0	25000.0	50000.0	100.0
Cali	kg	50.0	2400.0	120000.0	100.0
UREA	kg	50.0	1800.0	90000.0	100.0
Cow manure	bag	1.0	25000.0	25000.0	100.0
Construction material					
Black string for building pole support	kg	5.0	47000.0	235000.0	100.0
Irrigation pipes	pieces	2.5	90000.0	225000.0	100.0
Valve	number	1.0	20000.0	20000.0	100.0
Other					
Create rows by hilling up soil	person-day	2.0	25000.0	50000.0	100.0
Total costs for establishment of the Technology				**1259250.0**	

Maintenance activities

1. Watering in the morning and evening (Timing/ frequency: 2 times per day, 2-3 minutes per time)
2. Cutting the grass or branches of plant (3-4 braches) (Timing/ frequency: every 14 days per time during the growing period)
3. Spraying the pesticide if needed (Timing/ frequency: when damaged by insects)

4. Fixing the irrigaton pipes (Timing/ frequency: once per growing season)
5. Installing poles support for the melon (Timing/ frequency: once per growing season)

Maintenance inputs and costs (per 280 squre meters)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Thinning the branches	Person-day	1.0	25000.0	25000.0	100.0
Fixing the irrigation pipes	Person-day	1.0	20000.0	20000.0	100.0
Equipment					
Irrigation pipes	kg	8.0	4700.0	37600.0	100.0
Black strings for pole support	kg	7.0	4700.0	32900.0	100.0
Total costs for maintenance of the Technology				**115500.0**	

NATURAL ENVIRONMENT

Average annual rainfall
☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☑ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone
☐ humid
☑ sub-humid
☐ semi-arid
☐ arid

Specifications on climate
In 2015, the annual rainfall was 1225.7
In 2014, the annual rainfall was 1128.1
In 2013, the annual rainfall was 1316
Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)

Slope
☑ flat (0-2%)
☐ gentle (3-5%)
☐ moderate (6-10%)
☐ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☑ 0-100 m a.s.l.
☐ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☐ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☑ very deep (> 120 cm)

Soil texture (topsoil)
☐ coarse/ light (sandy)
☐ medium (loamy, silty)
☑ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☑ high (>3%)
☐ medium (1-3%)
☐ low (<1%)

Groundwater table
☐ on surface
☑ < 5 m
☐ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☑ good
☐ medium
☐ poor/ none

Water quality (untreated)
☐ good drinking water
☐ poor drinking water (treatment required)
☑ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☐ high
☑ medium
☐ low

Habitat diversity
☐ high
☑ medium
☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☐ mixed (subsistence/ commercial
☑ commercial/ market

Off-farm income
☐ less than 10% of all income
☑ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
☐ poor
☑ average
☐ rich
☐ very rich

Level of mechanization
☐ manual work
☐ animal traction
☑ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☑ women
☐ men

Age
☐ children
☐ youth
☑ middle-aged
☐ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha

Scale
☑ small-scale
☐ medium-scale

Land ownership
☐ state
☐ company

Land use rights
☐ open access (unorganized)
☐ communal (organized)

☐ 1-2 ha
☑ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

☐ large-scale

☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

☐ leased
☑ individual

Water use rights
☐ open access (unorganized)
☑ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor	☐☐☑	good
education	poor	☐☐☑	good
technical assistance	poor	☐☐☑	good
employment (e.g. off-farm)	poor	☐☑☐	good
markets	poor	☐☑☐	good
energy	poor	☑☐☐	good
roads and transport	poor	☑☐☐	good
drinking water and sanitation	poor	☐☑☐	good
financial services	poor	☐☐☑	good

IMPACTS

Socio-economic impacts

Crop production	decreased	☐☐☐☐☐☑☐	increased	The farmer used the coconut leaves mulch keeps good soil moisture and increase soil nutrient, thus increasing the crop production.
expenses on agricultural inputs	increased	☐☐☐☐☐☑☐	decreased	Farmer used raw material (coconut leaves) around her home that does not require any cost.
farm income	decreased	☐☐☐☐☐☑☐	increased	This technology improves soil moisture and soil nutrient, with less expense on the inputs as the coconut leaves are available around the house, thus the farm income increases.

Socio-cultural impacts

food security/ self-sufficiency	reduced	☐☐☐☐☐☑☐	improved	After the farmer applied this technology, she was able to better secure food consumption in her house, and as well she was able to sell the winter melons at the market to get more income for buying food.
health situation	worsened	☐☐☐☐☐☑☐	improved	The farmer grew winter melon without any chemical use. She ate healthy vegetable that improved the health situation accordingly.
SLM/ land degradation knowledge	reduced	☐☐☐☐☐☐☑	improved	Farmer knows how to conserve soil moisture and preserves the soil from erosion, and increases crop productivity through implementing this SLM technology as before her land was not good for planting vegetable. She tried to convert her land from infertile to fertile soil using animal manure (cow dung) mixed with topsoil from the hill.

Ecological impacts

evaporation	increased	☐☐☐☐☐☑☐	decreased	The technology area decreased the evaporation by using the coconut mulch as it keeps the soil moisture during the dry period.
soil moisture	decreased	☐☐☐☐☐☐☑	increased	The soil moisture is still remain even it dried for 3 days.
soil organic matter/ below ground C	decreased	☐☐☐☐☐☑☐	increased	The conversion from infertile to fertile soil using animal manure mixed with topsoil increased the amount of soil organic matter.
drought impacts	increased	☐☐☐☐☐☑☐	decreased	The improved soil moisture let the winter melon plant survive even at drought events of one week.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐☑☐	very positive
Long-term returns	very negative	☐☐☐☐☐☑☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative						✓		very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	**How the Technology copes with these changes/extremes**							
Gradual climate change								
annual temperature increase	not well at all			✓			very well	
seasonal temperature increase	not well at all			✓			very well	Season: summer
annual rainfall increase	not well at all			✓			very well	
Climate-related extremes (disasters)								
local rainstorm	not well at all			✓			very well	
flash flood	not well at all			✓			very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☐ 1-10%
☑ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☑ 10-50%
☐ 50-90%
☐ 90-100%

Number of households and/ or area covered
16 housholds of Chamkar Ou village implemented the technology (the one examined in this case study included)

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- This form of mulching is good for some farmers who do not have money for the purchase of plastic mulching materials.
- It provides good soil health and keeps a stable environment for humans.

Strengths: compiler's or other key resource person's view

- It is important that the farmers can understand the environment, and that they can also find low cost materials around their houses, such as coconut leaves mulch, because such materials will not pollute the soil and environment.
- Keep the soil quality using animal manure (cow dung)

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- It is difficult for first time implementation. → Try as much as possible to learn from the growing experience.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

REFERENCES

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Date of documentation: Aug. 23, 2017

Last update: Feb. 7, 2018

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_3152/

Linked SLM data
n.a.

Documentation was faciliated by
Institution

- Royal University of Agriculture (RUA) - Cambodia

Project

- Scaling-up SLM practices by smallholder farmers (IFAD)

Key references

- Lalljee, B., 2013. Mulching as a mitigation agricultural technology against land degradation in the wake of climate change. International Soil and Water Conservation Research, 1(3), pp. 68-74.: Free of charge

Links to relevant information which is available online

- Agricultural Technique Manual of Tonle Sap Poverty Reduction and Smallholder Development Project:http://www.tssdcambodia.org/

Vegetable cropping between mango tree rows (Mr. Kim Soben)

Crop rotation between mango trees in combination with drip irrigation (Cambodia)

Organic vegetable

DESCRIPTION

The rotational intercropping of vegetables between mango trees is a form of agroforestry. The technique aims to bear yield and income to the farmers when the trees do not bear fruit at young stage. Further purposes are the permanent soil cover which impede weed growth, reduces evaporation and soil erosion, and finally, in combination with drip irrigation it supports the adaptation to climate change.

Agroforestry is the practice of cultivating cash crops and/or the rearing of livestock on a plot of land together with growing trees such as fruit trees, coco trees, bamboo or other trees so as to improve agricultural output and gain other benefits (MoE et al., 2016). Agroforestry plays a vital role in providing ecological and economic benefits which include the harvest of timber and cash crops, improved soil fertility, reduced chemical fertilizer and pesticide input, reduced cost, better adaptation to climate change (MoE et al., 2016), as well as a reduced risk of crop failure (FA and DANIDA, 2005).

Mr. Hour is one of the farmers who shifted from monoculture to agroforestry. He is living with his family at Saob Krom Village, Saob Commune, Preaek Prasab District, Kratié Province (the northeastern province of Cambodia). On a hillside plot of 2100 square meters he has 135 mango trees planted in 9 rows with a space of 4 meters between each row and each tree. A number of different cash crops are intercropped in rotation between the rows of the mango trees which include amongst others: cucumbers, morning glory, cabbages and lettuce. The mango trees are cultivated after the land has been plowed and allowed to dry for 15 days. A dimension 0.5 meter of four-size hole with 0.5 meter deep is dug for each tree into which a 2 to 3kg mixture of cow manure, husk rice and bran that has been allowed to mature for 15 days is added. The farmer makes use of a drip irrigation system which extends to each tree and runs along the rows of the cash crops. The vegetable rows are prepared according to the season, as in the dry season ridge of the rows are 10 cm and in the rainy season they are 20 cm so as to prevent the vegetables being damaged by excessive amounts of water. Moreover, this technique does not cost much and generates income when the long-term crop is not yet ready to bear fruit. Additionally there are no negative impacts on the environment because the farmer applies liquid compost and bio-extract pesticide that he has produced on his own. The liquid compost is made up of a mixture of fish residue, bran and palm sugar mixed with water, which is then allowed to mature for around 15 days before it can be used. Meanwhile, the bio-pesticide is extracted from strong-smelling and bitter trees such as strychnine plants, yellow cheesewood, neem, boraphed and galangal. The materials are chopped into small pieces and mixed with palm sugar and water, which is then allowed to settle for at least 15 days before it is ready to be applied. In order to spray the crops, a liter of the liquid pesticide should be mixed with 25 liters of water.

All in all, this form of agroforestry brings a wide range of benefits. With this system, the farmer is able to generate an income from the different cash crops which can be harvested in both dry and rainy seasons especially in the first three years of the mango tree’s life when they are still unproductive. It therefore helps to reduce the financial burden of running the whole farm. This technique also helps to regulate the local micro-climate with the shade provided by the mango trees, reduces evaporation and soil erosion, as well as adapts to drought conditions that have been brought on by climate

LOCATION

Location: Saob Krom Village, Saob commune, Preaek Prasab District, Kratie Province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 105.95203, 12.43186

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 2015

Type of introduction

☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☑ through projects/ external interventions

change. Moreover, this practice avoids leaving a space between the trees that would otherwise enable the growth of unwanted weeds, which could also become a habitat for insects and the outbreak of diseases that lead to economic loss.

At first sight it may be a disadvantage that at the beginning the farmer has to raise a lot of money in order to install the drip irrigation system for example. However, once installed the system can last for many years which reduces labor costs related to irrigation. Regarding the cash crops the farmer also faces the challenge of unstable market prices. But if the prices are good and stable, the farmer is able to generate substantial income to improve the family's livelihood. Therefore, the institutions in charge need to take into account the market forces, too.


Cucumber and yard-long bean cropping between the mango row (Kim Soben)


Irrigation system for vegetable between the mango row (Kim Soben)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose
☑ improve production
☐ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use
Mixed (crops/ grazing/ trees), incl. agroforestry - Agroforestry
Main products/ services: Mango, cucumber, herbage vegetables, long bean and lettuce.

Water supply
☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 1

Land use before implementation of the Technology: Before it was degraded forest land with low fertility.

Livestock density: n.a.

Purpose related to land degradation
☐ prevent land degradation
☑ reduce land degradation
☑ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed
soil erosion by water - Wt: loss of topsoil/ surface erosion

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

biological degradation - Bc: reduction of vegetation cover

SLM group
- rotational systems (crop rotation, fallows, shifting cultivation)
- improved ground/ vegetation cover
- irrigation management (incl. water supply, drainage)

SLM measures
agronomic measures - A1: Vegetation/ soil cover

structural measures - S7: Water harvesting/ supply/ irrigation equipment

TECHNICAL DRAWING

Technical specifications

This practice is applied on a plot of 2100 square meters (width 35 meters x length 60 meters) situated on the hillside. It contains 135 mango trees (in 9 rows with the space of 4 meters between each row and tree) and a number of different cash crops grown in rotation among others: cucumber, morning glory, cabbage and lettuce. Drip irrigation system is spread to each tree and along cash row of the crops.

Author: Ms. Kongkea So and Mr. Sophea Tim

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **2100 square meters**)
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 20000 Riel

Most important factors affecting the costs

The costs for the pipe system are high.

Establishment activities

1. Plow and dry the land (Timing/ frequency: April)
2. Mango nursery (Timing/ frequency: April)
3. Dig holes, prepare pipe system (Timing/ frequency: April)
4. Prepare biotic pesticide and fertilizer (Timing/ frequency: April)
5. Mango plantation (Timing/ frequency: April)
6. Prepare soil and ridge of the rows for vegetable (Timing/ frequency: April)

Establishment inputs and costs (per 2100 square meters)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Plowing and raking	person-day	3.0	20000.0	60000.0	100.0
Digging the holes	person-day	5.4	20000.0	108000.0	100.0
Equipment					
Drip irrigation system	Set	1.0	800000.0	800000.0	100.0
Filter	piece	1.0	120000.0	120000.0	100.0
Spade	piece	2.0	15000.0	30000.0	100.0
Two-wheel tractor	piece	1.0	4800000.0	4800000.0	100.0
Plant material					
Mango trees	trees	135.0	5000.0	675000.0	100.0
Fertilizers and biocides					
Fish fertilizer	Liter	200.0	300.0	60000.0	100.0
Construction material					
Net	Piece	18.0	15000.0	270000.0	100.0
Bamboo trellising	Total	1.0	100000.0	100000.0	100.0
Total costs for establishment of the Technology				**7023000.0**	

Maintenance activities

1. Vegetable nursery (Timing/ frequency: April)
2. Vegetable transplanting (Timing/ frequency: April)
3. Do the trellising (Timing/ frequency: April)
4. Weeding (Timing/ frequency: First 10 days)
5. Spray biotic pesticide (Timing/ frequency: When pest existing)
6. Changing pipes (Timing/ frequency: When broken)

Maintenance inputs and costs (per 2100 square meters)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Prepare soil and ridge of the rows for vegetable	person-day	3.0	20000.0	60000.0	100.0
Vegetable transplanting	person-day	2.0	20000.0	40000.0	100.0
Weeding	person-day	9.0	20000.0	180000.0	100.0
Spray biotic pesticide	person-day	1.0	20000.0	20000.0	100.0
Equipment					
Pipe	Piece	3.0	100000.0	300000.0	100.0
Plant material					
Cucumber seed	pack	4.0	10000.0	40000.0	100.0
Long bean	pack	1.0	3500.0	3500.0	100.0
Fertilizers and biocides					
Bio-pesticide	liter	20.0	2000.0	40000.0	100.0
Other					
Changing pipes	person-day	1.0	20000.0	20000.0	100.0
Total costs for maintenance of the Technology				703500.0	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate

Average annual rainfall in mm: 1138.2
The average annual rainfall in 2015 is 1138.2 mm, in 2014 is 1696.5 mm in 2013 is 1661.8 mm.
Name of the meteorological station: Department of Meteorology, Ministry of Water Resources and Meteorology (2015)
There are two distinct seasons: dry season and rainy season.

Slope
- ☐ flat (0-2%)
- ☑ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☐ plateau/plains
- ☐ ridges
- ☑ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☑ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☐ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☑ very deep (> 120 cm)

Soil texture (topsoil)
- ☑ coarse/ light (sandy)
- ☐ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Topsoil organic matter content
- ☑ high (>3%)
- ☐ medium (1-3%)
- ☐ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☑ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☑ good
- ☐ medium
- ☐ poor/ none

Water quality (untreated)
- ☐ good drinking water
- ☐ poor drinking water (treatment required)
- ☑ for agricultural use only (irrigation)
- ☐ unusable

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☐ Yes
- ☑ No

Species diversity
- ☐ high
- ☐ medium
- ☑ low

Habitat diversity
- ☐ high
- ☐ medium
- ☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☐ mixed (subsistence/ commercial
- ☑ commercial/ market

Off-farm income
- ☐ less than 10% of all income
- ☑ 10-50% of all income
- ☐ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☐ poor
- ☑ average
- ☐ rich
- ☐ very rich

Level of mechanization
- ☑ manual work
- ☐ animal traction
- ☑ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative
- ☐ employee (company,

Gender
- ☐ women
- ☑ men

Age
- ☐ children
- ☐ youth
- ☑ middle-aged
- ☐ elderly

government)

Area used per household
- ☐ < 0.5 ha
- ☐ 0.5-1 ha
- ☐ 1-2 ha
- ☐ 2-5 ha
- ☐ 5-15 ha
- ☑ 15-50 ha
- ☐ 50-100 ha
- ☐ 100-500 ha
- ☐ 500-1,000 ha
- ☐ 1,000-10,000 ha
- ☐ > 10,000 ha

Scale
- ☐ small-scale
- ☑ medium-scale
- ☐ large-scale

Land ownership
- ☐ state
- ☐ company
- ☐ communal/ village
- ☐ group
- ☐ individual, not titled
- ☑ individual, titled
- ☑ Clear degraded forest

Land use rights
- ☐ open access (unorganized)
- ☐ communal (organized)
- ☐ leased
- ☑ individual

Water use rights
- ☐ open access (unorganized)
- ☐ communal (organized)
- ☐ leased
- ☑ individual

Access to services and infrastructure

health	poor		✓		good
education	poor		✓		good
technical assistance	poor			✓	good
employment (e.g. off-farm)	poor			✓	good
markets	poor		✓		good
energy	poor	✓			good
roads and transport	poor	✓			good
drinking water and sanitation	poor			✓	good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased						✓		increased	Due to the fact that he cultivates more crops than before on the same plot, the production increased. The farmer can continuously harvest because there are long-term crops and annual crops.
risk of production failure	increased						✓		decreased	As long-term and short-term crops are cultivated now, the risk of failure has been reduced.
product diversity	decreased						✓		increased	By thismixed system more than one crop variety is cultivated now.
production area (new land under cultivation/ use)	decreased						✓		increased	The former land was degraded forest land, now he is able to cultivate it by this SLM technology.
land management	hindered						✓		simplified	He cultivates more crops and using only organic fertilizer and botanical pesticide that is produced by himself.
expenses on agricultural inputs	increased						✓		decreased	Now he doesn’t have to buy chemical fertilizers anymore and he tries whenever possible to use biological pesticide produced by himself.
farm income	decreased							✓	increased	He gets income now all year round, because of the compination of short-term and long-term cultivation.
diversity of income sources	decreased					✓			increased	As more than one crop is cultivated on the plot, the diversity of income increased slightly.
workload	increased							✓	decreased	The good soil cover by intercrops prevents the weed growing and reduces the workload for weeding.

Socio-cultural impacts

food security/ self-sufficiency	reduced						✓		improved	As he cultivates more crops than before, the food security increased.
health situation	worsened						✓		improved	There is less environmental pollution as he uses organic fertilizers and biological pesticides. Thus, the health situation improved.
SLM/ land degradation knowledge	reduced						✓		improved	His knowledge regarding this technology has been improved due to experience and internet documents or videos.

Ecological impacts

soil moisture	decreased						✓		increased	More crops cover induces less soil evaporation.
soil cover	reduced						✓		improved	Due to the vegetable intercropping the soil cover improved.

soil compaction	increased						✓		reduced	The roots of the mango trees are very good against soil compaction.
vegetation cover	decreased						✓		increased	Due to permanent crop cover all over the year.
invasive alien species	increased						✓		reduced	Invasive alien species are reduced due to crop rotation and biologial pesticide application.
beneficial species (predators, earthworms, pollinators)	decreased						✓		increased	Beneficial species are increased because of liquid compost using.
pest/ disease control	decreased						✓		increased	The own-produced bio pesticides are very effective.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative						✓		very positive

Benefits compared with maintenance costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative							✓	very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes							
Gradual climate change								
annual temperature increase	not well at all				✓		very well	
seasonal temperature increase	not well at all				✓		very well	Season: wet/ rainy season
seasonal temperature increase	not well at all				✓		very well	Season: dry season
annual rainfall decrease	not well at all			✓			very well	
seasonal rainfall increase	not well at all				✓		very well	Season: wet/ rainy season
The rain is changed because it doesn't rain until July.	not well at all						very well	
Climate-related extremes (disasters)								
local rainstorm	not well at all			✓			very well	
heatwave	not well at all		✓				very well	
cold wave	not well at all				✓		very well	
extreme winter conditions	not well at all			✓			very well	
epidemic diseases	not well at all				✓		very well	
insect/ worm infestation	not well at all				✓		very well	
Other climate-related consequences								
There is no problems because it has water sources and irrigation systems.	not well at all						very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☑ single cases/ experimental
☐ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Less labor is required due to the use of the drip irrigation system.
- Various products which makes it easier to respond to the demands of the market.
- Efficient use of land which does not allow grass growing.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Lack of financial capital. → Access funds from micro finance firms at low interest rate, or supports from project and the state.
- Unstable market price. → Forming farmer groups and seek

Strengths: compiler's or other key resource person's view
- Less labor is required because the drip irrigation system is used to water the crops and to apply fertilizer.
- An environmentally friendly technology without any use of machines and in consequence fuel for irrigation by using ram pump.
- A good soil management technique that enables interactive benefits among crops and trees.
- Improves the soil's fertility as various cover crops are rotated.

for support from NGOs and/or institutions in charge.
- Cover a large expense at the beginning in order to install the drip irrigation system. → Susidies from projects, relevant NGOs and government.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome
- When mango trees growth up and branches spread out, he could not plant anymore these kinds of vegetable (cucumber, morning glory, etc), as they need light. → Plant other crops that do not need much light and are resistant to shade.

REFERENCES

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Date of documentation: May 14, 2017

Last update: Jan. 24, 2018

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_2236/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

Key references

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Reusing newspapers to protect fruits and using bamboo branches as the trellising (Mr. Tim Sophea)

Bitter gourd cultivation using recycled newspapers to protect fruits (Cambodia)

Bitter gourd cultivation

DESCRIPTION

The use of old newspapers to wrap up bitter gourd, so as to prevent the fruit from being damaged by insects, and to protect them from direct sunlight and contact with pesticides. This agricultural approach only uses animal manure, fish heads and urea (46-0-0) as fertilizer to improve the soil's quality.

Bitter gourd is a crop that can be supported by trellises and it is possible to plant it throughout the year. However it is not recommended to grow it in areas with strong winds because then it takes longer to grow. Bitter gourd requires more fertile soil than other varieties in the Cucurbitaceae family. It needs to be well-saturated or loamy soil with a pH of 6 to 6.8. The most suitable land can be found along river banks, streams, and lakes with high silt content. Bitter gourds are susceptible to be damaged by pests and diseases. In order to protect the fruit from pests, plastic, paper or other materials are wrapped around the fruit. Additionally, the crop needs nets for climbing, which can be quite expensive (Agritoday, 2016).

In this case study the farmer plants bitter gourds by using bamboo sticks to construct the trellis for plant climbing. And he wraps up the fruits with old newspapers. This growing technique is less expensive than using nets for plant climbing and medium A4 sized brown paper envelopes to protect the fruit. The bamboo sticks can be used for two years, and during this period the farmer is able to make use of them three to four times a year. The newspapers that have been bought to protect the fruit can be used two or three times, so as not only to reduce the cost but also to reduce the environmental impact. Covering the fruit with newspapers is better than using plastic bags or pages from books, because plastic bags can easily become too hot, and pages are particularly vulnerable to rain or water. The main purpose of wrapping up the bitter gourd with newspapers is to protect them from insects, especially the fruit fly. However it also protects them from the heat of the sun makes the fruit whiter, and acts as a protection against pesticides as this would otherwise be directly sprayed onto the fruit. Insecticides normally last an average of 7 to 10 days and plants will then have to be sprayed again to prevent the return of the insects. Farmers are able to harvest the bitter gourd about 15 days after pinned with newspaper.

As the area is flooded by the Mekong River during the months of August - October, it is not possible to plant bitter gourd in the rainy season. After the water has receded the soil should be ploughed and dried by the sun for 15 days. After this the soil should be plowed again, and then the field needs to be harrowed evenly and the soil left to dry for three more days. Fertilizers should not be added whilst ploughing. Planting is done by firstly using a hoe to scratch a central trench in the field. Further parallel lines to this trench should be 1.2 meters apart and the bitter gourd seeds should then be planted along the lines, at 40 centimeter intervals. Once the seeds are in the ground manure, cow or buffalo compost should be applied over the top and then watered. Before growing, it should be soaked for 2 hours and then covered with cloth. Afterwards they should be left to soak in a steady flow of water for 4 to 5 days until the shoots begin to grow. After when the developing bitter melon is 15 days old a bamboo pole with bamboo sticks of about 1.7 meters height and 10 cm from the plants has to be placed. A further 15 days after having put up the poles, the soil should be loosen up again and then the fish head fertilizer mixed with a little bit of UREA is applied. The fertilizer should be

LOCATION

Location: Floodplain which is flooded from August until September, Preaek Roka village, Saob commune, Preaek Prasap district, Kratie province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites
- 106.01298, 12.45532

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 10-50 years ago

Type of introduction
- ☐ through land users' innovation
- ☑ as part of a traditional system (> 50 years)
- ☐ during experiments/ research
- ☐ through projects/ external interventions

spread about 30 to 40 cm from plants, or it can be added between the bitter gourd clumps, which can also be combined with manure and UREA. Watering should be done twice a day, once in the morning and once in the evening. The irrigation system involves pumping water from a nearby lake. Even though pesticides are used regularly, if paper is not used to protect the fruits, they can still be affected by pests. Once affected the fruit falls down, becomes stunted, grows into irregular shapes, the color becomes dull. In case the fruit were directly affected by the poison it could be harmful to people's health. Any combination of these physical symptoms can be identified very easily and monitored by the farmers themselves. Since the use of this technique the farmer's income has increased because they are able to grow a product of good quality and high output.


Using newspaper to wrap up the bitter gurd fruits (Mr. Tim Sophea)


Farmer is wrapping up fruits with old newspaper (Mr. Tim Sophea)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- ☑ improve production
- ☐ reduce, prevent, restore land degradation
- ☐ conserve ecosystem
- ☐ protect a watershed/ downstream areas – in combination with other Technologies
- ☐ preserve/ improve biodiversity
- ☐ reduce risk of disasters
- ☐ adapt to climate change/ extremes and its impacts
- ☐ mitigate climate change and its impacts
- ☐ create beneficial economic impact
- ☐ create beneficial social impact
- ☑ Protecting fruit from insects

Land use

Cropland - Annual cropping
Main crops (cash and food crops): Bitter melon which can harvested during around 1,5 month.

Water supply

- ☐ rainfed
- ☑ mixed rainfed-irrigated
- ☐ full irrigation

Number of growing seasons per year: 2

Land use before implementation of the Technology: Before this land was planted by corn, cucumber, and sesame.

Livestock density: n.a.

Purpose related to land degradation

- ☑ prevent land degradation
- ☐ reduce land degradation
- ☐ restore/ rehabilitate severely degraded land
- ☐ adapt to land degradation
- ☐ not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

biological degradation - Bc: reduction of vegetation cover, Bl: loss of soil life

SLM group

- integrated soil fertility management
- integrated pest and disease management (incl. organic agriculture)

SLM measures

agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility

other measures -

TECHNICAL DRAWING

Technical specifications

The size of the plot of land is 2100 square meters (a width of 30 meters x a length of 70 meters) containing 25 rows, which are about 70 meters in length and 1.2 meters apart from each other. Along each row there is a distance of 40 cm between each plant and the trellises have a height of 1.70 meters. Then the fruit have been wrapped with newspaper to protected from sunlight, insects and pesticide applied, and also to keep the fruit white.

Author: Dr. So Than and Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **2100 square meters**)
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 20000 Riel

Most important factors affecting the costs

High costs for pumping machine, fish head fertilizer and compost.

Establishment activities

1. First plow is keeping 15 days (Timing/ frequency: December)
2. Second plow is keeping 3 days (Timing/ frequency: December)
3. Nursery and propagation (Timing/ frequency: December)
4. Draw the line and planting (Timing/ frequency: January)
5. Watering (Timing/ frequency: January)
6. Collection of bamboo branches (Timing/ frequency: November)
7. Prepare fish head fertilizer, compost, and urea (46-0-0) (Timing/ frequency: August or September)
8. Prepare newspaper for wrap up fruits (Timing/ frequency: December)
9. Buying the tools such as spade, knife, large basket, and water pumping machine. (Timing/ frequency: November)
10. Self keeping seeds (Timing/ frequency: March)

Establishment inputs and costs (per 2100 square meters)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Nursery and watering	peson-day	3.5	20000.0	70000.0	100.0
Plowing 2 times	peson-day	3.75	20000.0	75000.0	100.0
Draw the line and planting	peson-day	8.0	20000.0	160000.0	100.0
Equipment					
Pumping machine	piece	1.0	1600000.0	1600000.0	100.0
Spade	piece	2.0	20000.0	40000.0	100.0
Knife	piece	2.0	20000.0	40000.0	100.0
Large basket	pair	1.0	5000.0	5000.0	100.0
Plant material					
Seeds	seed	3000.0	60.0	180000.0	100.0
Fertilizers and biocides					
Fish head fertilizer, compost and urea	kg	200.0	2500.0	500000.0	100.0
Construction material					
Bamboo branches	piece	100.0	5000.0	500000.0	100.0
Other					
Newspaper	kg	40.0	1000.0	40000.0	100.0
Spraying tank	piece	1.0	80000.0	80000.0	100.0
Total costs for establishment of the Technology				3290000.0	

Maintenance activities

1. Making soil soft and adding fertilizer (Timing/ frequency: after the plants are 15 days old)
2. Adding more soil at bottom of plants, putting fertilizer and trellising (Timing/ frequency: After making the soil soft during 15 days)
3. Watering (Timing/ frequency: Everyday (morning and evening))
4. Checking for insects (Timing/ frequency: Everyday)
5. Wrap up fruits with newspaper (Timing/ frequency: When fruits are provided)
6. Spraying pesticide to prevent insects (Timing/ frequency: When insects are appeared)
7. Spraying fish head fertilizer, animals manure, and urea (Timing/ frequency: 3 times for life cycle)

Maintenance inputs and costs (per 2100 square meters)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Making the soil to be soft, adding more soil at bottom of plants, and trellising	person-day	8.0	20000.0	160000.0	100.0
Fertilizers and biocides					
Urea (46-0-0))	kg	6.0	2500.0	15000.0	100.0
Pesticide	bottle	2.0	15000.0	30000.0	100.0
Fish head	kg	50.0	600.0	30000.0	100.0
Other					
Gasoline to pumping for irrigation (3 months)	liter	45.0	3200.0	144000.0	100.0
Total costs for maintenance of the Technology				379000.0	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate

Average annual rainfall in mm: 1138.2

The average annual rainfall in 2015 is 1138.2 mm, in 2014 is 1696.5 mm in 2013 is 1661.8 mm.

Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)

The weather is hot and humid that contain two seasons, dry and rainy season, and last year the weather was warmer than every year.

Slope
- ☑ flat (0-2%)
- ☐ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☑ plateau/plains
- ☐ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☑ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☑ concave situations
- ☐ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☐ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☑ very deep (> 120 cm)

Soil texture (topsoil)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Topsoil organic matter content
- ☐ high (>3%)
- ☑ medium (1-3%)
- ☐ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☐ 5-50 m
- ☑ > 50 m

Availability of surface water
- ☐ excess
- ☑ good
- ☐ medium
- ☐ poor/ none

Water quality (untreated)
- ☐ good drinking water
- ☐ poor drinking water (treatment required)
- ☑ for agricultural use only (irrigation)
- ☐ unusable

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☑ Yes
- ☐ No

Species diversity
- ☐ high
- ☐ medium
- ☑ low

Habitat diversity
- ☐ high
- ☐ medium
- ☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☑ mixed (subsistence/ commercial
- ☐ commercial/ market

Off-farm income
- ☑ less than 10% of all income
- ☐ 10-50% of all income
- ☐ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☐ poor
- ☑ average
- ☐ rich
- ☐ very rich

Level of mechanization
- ☑ manual work
- ☐ animal traction
- ☑ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic
- ☑ During flood he cultivates at other places.

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative
- ☐ employee (company, government)

Gender
- ☐ women
- ☑ men

Age
- ☐ children
- ☐ youth
- ☑ middle-aged
- ☐ elderly

Area used per household
- ☐ < 0.5 ha

Scale
- ☐ small-scale

Land ownership
- ☐ state

Land use rights
- ☐ open access (unorganized)

☐ 0.5-1 ha
☐ 1-2 ha
☑ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

☑ medium-scale
☐ large-scale

☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled
☑ Hire

☐ communal (organized)
☑ leased
☑ individual
☑ Hire

Water use rights
☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor	☐	☐	☑	good
education	poor	☑	☐	☐	good
technical assistance	poor	☑	☐	☐	good
employment (e.g. off-farm)	poor	☑	☐	☐	good
markets	poor	☐	☑	☐	good
energy	poor	☑	☐	☐	good
roads and transport	poor	☐	☑	☐	good
drinking water and sanitation	poor	☐	☑	☐	good
financial services	poor	☑	☐	☐	good

IMPACTS

Socio-economic impacts

crop quality	decreased	☐	☐	☐	☐	☐	☐	☑	increased	Using newspaper to wrap up is making the bitter melon healthier.
expenses on agricultural inputs	increased	☐	☐	☐	☐	☐	☑	☐	decreased	The expenses on agricultural inputs are reduced due to less use of chemical fertilizer (little use of mixture of urea, animals manure and fish head fertilizer) and less expenses as instead of expensive nets he uses bamboo sticks and also he uses cheaper newspaper for fruit protection.
farm income	decreased	☐	☐	☐	☐	☐	☑	☐	increased	The income is increased due to reduction of insects damaging.
workload	increased	☐	☐	☑	☐	☐	☐	☐	decreased	It is increased a bit because he has to wrap up all fruits.

Socio-cultural impacts

Ecological impacts

pest/ disease control	decreased	☐	☐	☐	☐	☐	☑	☐	increased	This newspaper wrap up technique controls only pest.

Off-site impacts

impact of greenhouse gases	increased	☐	☐	☐	☐	☐	☑	☐	reduced	Reused of newspaper and bamboo branches for optimizing.

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐	☐	☐	☐	☐	☑	☐	very positive
Long-term returns	very negative	☐	☐	☐	☐	☐	☑	☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐	☐	☐	☐	☐	☑	☐	very positive
Long-term returns	very negative	☐	☐	☐	☐	☐	☑	☐	very positive

Looking for job sees to be less profitable than growing vegetables. Bitter melon can be harvested during half a month and could be cultivated twice a year.

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed

How the Technology copes with these changes/extremes

Gradual climate change

annual temperature increase	not well at all	☐	☐	☑	☐	☐	very well	
seasonal rainfall increase	not well at all	☐	☐	☑	☐	☐	very well	Season: wet/ rainy season

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Number of households and/ or area covered

There are about 6 families in the village who practice this technique as well.

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Gain of a variety of benefits because they do not have to hire labor or buy bamboo sticks and they have animal manure.
- Reduced use of chemical fertilizers as instead they are using fish head fertilizer.

Strengths: compiler's or other key resource person's view

- Bamboo sticks do not cause additional costs because they can be gathered for free.
- Using newspapers does not cause negative environmental impacts compared to the the use of plastic and it also reduces the need for pesticides.
- Fish head fertilizer and animal manure helps to improve the soil's fertility and reduces the need for chemical fertilizer.
- Reduced cost of planting materials.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Pesticide was applied without protection of the fruit but it did not work. → Wrap up bitter gourd in newspaper before applying pesticide and then check the fruit regularly.
- No water in the pond during the dry season. → Use water from the river by pumping instead.
- Expense of buying pipes to pump water from a distant source. → Borrow from others and take a loan from retailers.
- Low market price of the bitter gourd. → There is no solution for market yet.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

REFERENCES

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Date of documentation: April 25, 2017

Last update: March 30, 2018

Resource persons
Sopheak Song (N/A) - Saob commune extension worker
Sophea Tim (stim3993@gmail.com) - Deputy director of Center for Agricultural and Environmental Studies, RUA
Sivin Sak (saksivin@gmail.com) - Agricultural office chief in Sambo district
Chanak Houn (N/A) - land user
Saravuth Ly (N/A) - Official of Chetr Borei district office of agriculture, forestry and fisheries

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_2101/

Linked SLM data
n.a.

Documentation was faciliated by
Institution

- Royal University of Agriculture (RUA) - Cambodia

Project

- Scaling-up SLM practices by smallholder farmers (IFAD)

Links to relevant information which is available online

- Agritoday (2016). Bitter Gourd. Retrieved December 06, 2017: http://agritoday.com/view/2084.html


Intercropping of mung bean between banana (Mr. Tim Sophea)

Intercropping of mung bean and banana in the uplands (Cambodia)

Growing mug bean with banana

DESCRIPTION

Intercropping of mung beans with bananas adds nutrients to the soil, and generates further income while waiting for the yield of the banana trees.

The root nodules of mung beans contain rhizobium bacteria that can absorb and store nitrogen from the environment. This is good for any nearby crops, and after the harvest when the field is plowed it improves soil's nutrient levels (CARDI, 2011). The mung beans residue such as stems, leaves, and shells actively leads to an improvement of the soil's quality and fertility by increasing the nitrogen level in the soil. Mung beans are mostly grown in March with the seeds being directly placed into pits dug at regular intervals (MAFF, 2005). Bananas are a high-moisture providing crop to the soil, and their root systems add air to the soil and enrich it with humus. Regarding the plantation of banana seedlings, their pits should be 30 cm in depth and should measure 0.5 m x 0.5 m, with a space of 2 meters between each plant (Our Agricultural Market, 2017).

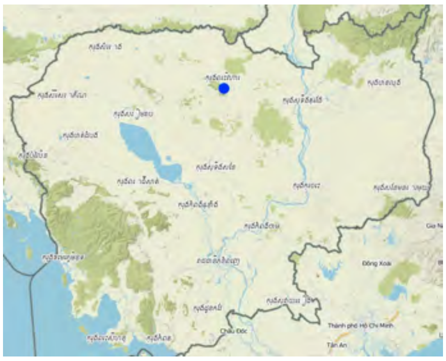
Mrs. Sophea Mun has been living in the upland village known as Andoung Preang, in Preah Khleang commune, Tbaeng Mean Chey district, Preah Vihear province, Cambodia. She was selected for this case study because she has been applying the technique of mung beans intercropped by bananas and thereby contributing to sustainable land management.

One of the reasons for intercropping mung beans between banana trees is to help improve the soil's fertility by retaining the decomposing residue of the plants in the space between the bananas to act as an organic fertilizer. Moreover, as the cover crop, mung beans also play a role in reducing soil erosion by water and preventing weeds from competing with the growth of the banana trees.

Whilst the technology has beneficial impacts on the soil; it also increases the farmers' income before the bananas are able to produce a yield. Bananas are the long-term crop and so at the time when they are not yet generating a financial output, the mung beans act as an important source of income to support the farmers' livelihoods. Banana trees can first be harvested after 10 months and will then produce a higher yield over the second year. The yield will then start to decrease once trees reach the age of six or seven, and once this happens they are cut down. The mung beans are the short-term crop and can be harvested and sold after 3 months and can be grown twice in one season. Generally, when the banana trees are 2 or 3 years old it is not possible to grow mung beans because they provide too much shade and there is not enough sunlight.

The farmer uses about 22 kg of mung bean seeds on a plot of land measuring 70 x 200 meters. The seedlings are planted directly between the banana trees, instead of being broadcast because in this way the seedlings will have enough space between them to allow for ventilation, and ultimately will produce a higher yield. In this case study, the farmer firstly grows mung beans and once these have been harvested will grow soybeans in July and is therefore able to grow twice in one season. Bananas should be planted in rectangular pits measuring 20cm x 30 cm with a depth of 0.5 meters. There should be a space of 4 meters between each of the plants and a distance of 5 meters between the rows. They should be grown in February when there is no rain so that the banana seedlings can flourish. If they are cultivated in the rainy season, they are often vulnerable to mealybugs and do not grow as well as in the dry season.

LOCATION



Location: Andoung Preang village, Preah Khleang commune, Tbaeng Mean Chey district, Preah Vihear province , Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 104.99651, 13.67053

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: less than 10 years ago (recently)

Type of introduction

☐ through land users' innovation
☑ as part of a traditional system (> 50 years)
☐ during experiments/ research
☐ through projects/ external interventions

Growing mung beans by direct seedling in line between banana (Mr. Tim Sophea)

Mung bean plants are flowering and fruiting (Mr. Tim Sophea)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- ☐ improve production
- ☑ reduce, prevent, restore land degradation
- ☐ conserve ecosystem
- ☐ protect a watershed/ downstream areas – in combination with other Technologies
- ☐ preserve/ improve biodiversity
- ☐ reduce risk of disasters
- ☐ adapt to climate change/ extremes and its impacts
- ☐ mitigate climate change and its impacts
- ☑ create beneficial economic impact
- ☐ create beneficial social impact

Land use

Cropland - Annual cropping, Perennial (non-woody) cropping
Main crops (cash and food crops): Mung bean/soybean and banana

Water supply

- ☑ rainfed
- ☐ mixed rainfed-irrigated
- ☐ full irrigation

Number of growing seasons per year: 2
Land use before implementation of the Technology: n.a.
Livestock density: No animal raising

Purpose related to land degradation

- ☑ prevent land degradation
- ☐ reduce land degradation
- ☐ restore/ rehabilitate severely degraded land
- ☐ adapt to land degradation
- ☐ not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion

biological degradation - Bl: loss of soil life

SLM group

- improved ground/ vegetation cover

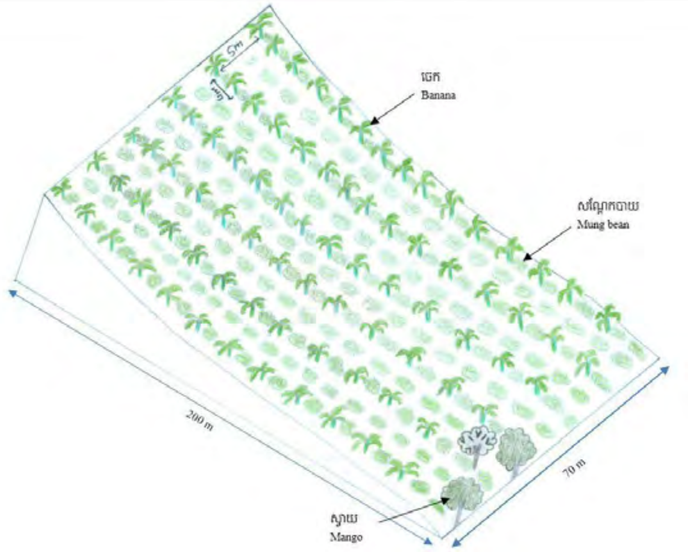
SLM measures

agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility, A3: Soil surface treatment

TECHNICAL DRAWING

Technical specifications

The farmers intercrop mung beans with bananas on the same plot (70m x 200m=14000 square meters and slope of 30-degree). The space between each row of bananas is 5 meters and space between each banana plant is 4 meters, amounting to a total of 600 banana trees. The mung beans can be directly planted in a row between the banana trees by placing two or three seeds in one hole with a depth of 3 to 4 cm. On this piece of land the farmer planted 22 kg of mung bean seeds.



Author: Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **70 X 200= 14000 square meters**)
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 20000 Riel

Most important factors affecting the costs

Buying seeds and hiring labor for digging the holes

Establishment activities

1. Pick out the cassava stem (Timing/ frequency: When starting grow mung bean)
2. Ploughing and drying the soil (Timing/ frequency: January)
3. Buying the banana tree seedlings (Timing/ frequency: February)
4. Digging the holes for the banana seedlings and planting (Timing/ frequency: March)
5. Buying mung bean seed (Timing/ frequency: March)
6. Buy hoe (Timing/ frequency: March)

Establishment inputs and costs (per 70 X 200= 14000 square meters)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Ploughing and drying the soil	person-day	3.6	20000.0	72000.0	100.0
Digging the hole for the banana seedlings and planting	person-day	1.5	20000.0	30000.0	100.0
Equipment					
Hooked knife	piece	5.0	25000.0	125000.0	100.0
Hoe	piece	3.0	20000.0	60000.0	100.0
Plant material					
Banana seedlings	seedling	600.0	300.0	180000.0	100.0
Total costs for establishment of the Technology				**467000.0**	

Maintenance activities

1. Soil preparation and direct seedling of mung beans (Timing/ frequency: March)
2. Spray the herbicide (Timing/ frequency: 20 days after mung bean sowing)
3. Weeding (Timing/ frequency: Every month)
4. Spray the fattening fertilizer (Timing/ frequency: After first harvesting)

Maintenance inputs and costs (per 70 X 200= 14000 square meters)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Soil preparation and direct seedling of mung beans	person-day	2.0	20000.0	40000.0	100.0
Spray the herbicide and weeding	person-day	10.0	20000.0	200000.0	100.0
Spray the fattening fertilizer	person-day	1.0	20000.0	20000.0	100.0
Harvesting	person-day	12.0	20000.0	240000.0	100.0
Plant material					
Mung bean	kg	24.0	12000.0	288000.0	100.0
Fertilizers and biocides					
Herbicide	liter	2.0	12000.0	24000.0	100.0
Fattening fertilizer	liter	2.0	11000.0	22000.0	100.0
Total costs for maintenance of the Technology				**834000.0**	

NATURAL ENVIRONMENT

Average annual rainfall
☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☐ 1,001-1,500 mm
☑ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone
☐ humid
☑ sub-humid
☐ semi-arid
☐ arid

Specifications on climate
Average annual rainfall in mm: 1429.3
The annual rainfall in 2015 is 1429.3 mm. In 2014 is 1647.3 mm.
Name of the meteorological station: Ministry of water resources and meteorology (2015)
There are 2 seasons, dry season and rainy season.

Slope
☐ flat (0-2%)
☐ gentle (3-5%)
☐ moderate (6-10%)
☐ rolling (11-15%)
☑ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☐ plateau/plains
☐ ridges
☑ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☐ 0-100 m a.s.l.
☑ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☑ convex situations
☐ concave situations
☐ not relevant

Soil depth
☐ very shallow (0-20 cm)
☐ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☑ very deep (> 120 cm)

Soil texture (topsoil)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☑ medium (1-3%)
☐ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☐ good
☑ medium
☐ poor/ none

Water quality (untreated)
☐ good drinking water
☐ poor drinking water (treatment required)
☑ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☐ high
☑ medium
☐ low

Habitat diversity
☐ high
☑ medium
☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☐ mixed (subsistence/ commercial
☑ commercial/ market

Off-farm income
☐ less than 10% of all income
☑ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
☑ poor
☐ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☐ animal traction
☑ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☑ women
☐ men

Age
☐ children
☐ youth
☑ middle-aged
☐ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☑ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☑ small-scale
☐ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled
☑ ជួលគេ

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☑ leased
☐ individual

Water use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual
☑ rain-fed

Access to services and infrastructure

health	poor	🟧	✓	🟩	good
education	poor	🟧		✓	good
technical assistance	poor	✓		🟩	good
employment (e.g. off-farm)	poor	🟧	✓	🟩	good

markets	poor	☐ ✓ ☐	good
energy	poor	☐ ☐ ✓	good
roads and transport	poor	☐ ☐ ✓	good
drinking water and sanitation	poor	☐ ☐ ✓	good
financial services	poor	☐ ☐ ✓	good

IMPACTS

Socio-economic impacts				
Crop production	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Continuous harvest of long-term and short-term crops
crop quality	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	Use less of chemical fertilizer and shifting crops.
risk of production failure	increased	☐ ☐ ☐ ☐ ✓ ☐ ☐	decreased	Insect invasion has been reduced.
product diversity	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	As banana and mung beans are cultivated, the product diversity increased
land management	hindered	☐ ☐ ☐ ☐ ☐ ✓ ☐	simplified	Mung beans and soybeans help to improve soil fertility especially regarding nitrogen, and thus, less chemical fertilizing is needed. Further, the soil cover by the beans between the banana plants prevents weeding.
expenses on agricultural inputs	increased	☐ ✓ ☐ ☐ ☐ ☐ ☐	decreased	Farmers spend more money for wage labor.
farm income	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Before, the farmer cultivated cassava which he harvested only once a year. But now, she cultivates banana with bean that can be harvested twice a year until the banana is able to produce yield.
diversity of income sources	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	Now, income is generated from both from mung beans (or soybeans) and banana.
Socio-cultural impacts				
food security/ self-sufficiency	reduced	☐ ☐ ☐ ☐ ☐ ✓ ☐	improved	It is improved due to the cultivation of more then only one crop (banana and mung beans or soybeans).
SLM/ land degradation knowledge	reduced	☐ ☐ ☐ ☐ ✓ ☐ ☐	improved	The farmer learned from this cultivation method, (Mung beans or soybeans between banana trees) that soil erosion can be reduced and soil fertility can be improved.
Ecological impacts				
soil moisture	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Banana cultivation with mung beans or soybeans improved the soil moisture due to better soil cover (less soil evaporation).
soil cover	reduced	☐ ☐ ☐ ☐ ☐ ✓ ☐	improved	Due to the Mung beans or soybeans plants between banana trees, the soil cover is improved.
soil loss	increased	☐ ☐ ☐ ☐ ☐ ✓ ☐	decreased	Due to annual crops cover.
soil organic matter/ below ground C	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	Enrichment of nitrogen due to the bean cultivation, due to nitrogen-fixing Bacterium in their roots.
vegetation cover	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Due to the mung beans or soybeans plants between banana trees, the vegetation cover has been improved. Mung beans or soybeans help to prevent soil erosion and keep the soil moisture.
beneficial species (predators, earthworms, pollinators)	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Increase e.g. of mole cricket and earth worms

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs			
Short-term returns	very negative	☐ ☐ ☐ ☐ ☐ ✓ ☐	very positive
Long-term returns	very negative	☐ ☐ ☐ ☐ ☐ ✓ ☐	very positive
Benefits compared with maintenance costs			
Short-term returns	very negative	☐ ☐ ☐ ☐ ☐ ✓ ☐	very positive
Long-term returns	very negative	☐ ☐ ☐ ☐ ☐ ✓ ☐	very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes			
Gradual climate change				
annual temperature increase	not well at all	🟧🟧⬜🟩🟩	very well	Answer: not known
seasonal temperature increase	not well at all	🟧🟧⬜🟩🟩	very well	Season: wet/ rainy season Answer: not known

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☐ 1-10%
☑ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Number of households and/ or area covered
Several housholds (the exact amount is not known)

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Optimal land use of a given plot, providing the opportunity to plant two crops.
- Generate an income from the short term crop before the long term crop provides a yield.
- Prevents grass from growing because it is not given the opportunity with the crop growing on the land instead.

Strengths: compiler's or other key resource person's view

- Mung beans are a short-term crop which also add supplementary nutrients to the soil.
- A reduction in soil erosion because of the natural crop cover.
- Provides an income for households whilst the bananas have not yet produced a yield.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Appearance of worms. → Application of pesticides according to standardized practices.
- Lack of a water source for irrigation. → Depends on the rainfall

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

REFERENCES

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Date of documentation: Feb. 24, 2017

Last update: May 29, 2018

Resource persons
Sophea Mun (N/A) - land user
Phol Prom (prom.phol2017@gmail.com) - Chief of Agricultural Office of Kuleaen District
Chlat Prachnha (N/A) - Official of Agricultural Office of Choam Khsant District
Kuychhun Cheng (N/A) - Chief of Agricultural Office of Rovieng District

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_1890/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

Key references

- CARDI (2011) Growing mungbean on sandy soil after harvesting wet season rice. Farmer Nowslette.(In Khmer Language)Retrieve on May 03, 2018,from: http://www.maff.gov.kh/agri-tech/56%E1%9E%8A%E1%9F%86%E1%9E%8E%E1%9E%B6%E1%9F%86%E1%9E%A7%E1%9E%9F%E1%9F%92%E1%9E%9F%E1%9E%B6%E1%9E%A0%E1%9E%80%E1%9E%98%E1%9F%92%E1%9E%98/%E1%9E%80%E1%9E%B6%E1%9E%9A%E1%9E%8A%E1%9E%B6%E1%9F%86%E1%9E%8A%E1%9E%BB%E1%9F%87%E1%9E%9F%E1%9E%8E%E1%9F%92%E1%9E%8F%E1%9F%82%E1%9E%80/961-bean-after-rainy-harvest.html
- MAFF(2005) Mungbean. (In Khmer language) Retrieve on May 03, 2018, from : https://docs.google.com/file/d/0B3kkBprEzhDobllqbnFrVmVGTGM/view

Links to relevant information which is available online

- Our Agricultural Market(2017) Good techniques for farmers who want to grow banana to generate income.(In Khmer language)Retrieve on May 03, 2018, from: https://www.e-oam.com/?p=3071


Crop diversification (Mr. Sok Pheak)

Crop diversification with the application of rotation techniques (Cambodia)

Crop diversification farm

DESCRIPTION

Crop diversification is the practice of simultaneously cultivating two or multiple varieties of crops in a given area whilst at the same time applying crop rotation and/or intercropping. In this case study the land user has been practicing crop diversification with eleven different crop varieties.

Crop diversification entails simultaneously growing two or multiple varieties of crops in a particular place with the application of crop rotation techniques and/or intercropping. The selection of the crop varieties will depend on the purpose of the land user. In general, a diversity of crops will provide a range of benefits such as food security, nutritional diversity, income generation, soil conservation, pest and disease control as well as adaptation to climate change (CGIAR, 2017, Makate et al, 2016, MoEYS& VVOB Cambodia, 2013).

Mrs. Prum Thon has been cultivating a diversity of crops with the application of rotation techniquesfor about 10 years, which involves exchanging an entire crop in a particular row. This means that cultivation can take place throughout the year without having to leave the land fallow. At the time of the interview eleven different crops had been cultivated including spring onions, anise basil, Cambodian mint, bok choy, choy sum, escarole, mint, long beans, cucumbers, bitter melons and lettuce. Almost all of these crops have an average lifespan of three months, except for the anise basil which can grow for one or two years depending on the way it is cultivated. After she has harvested a particular crop, she will then rotate this crop row with a new distinctive crop species. For instance after having harvested spring onions she will then plant mint in that row, and in the row where she was previously growing mint, she will rotate that with either spring onions or cucumbers.

The practice of crop diversification whilst at the same time rotating the crop in each of the rows aims to achieve the following main objectives:

Crop diversification enables the farmer to generate a daily income to offset her daily expenses which thereby becomes a means of improving her livelihood. Growing a diversity of crops can also enable her to meet a variety of market demands and generate a high daily income. If a farmer grows only one crop specie she can usually earn about 15,000 Riel per day, but if she plants four crop species such as anise basil, bok choy, long beans and cucumbers she can increase her income to about 20,000 Riel per day, However if she grows one more specie such as lettuce or grows eleven different crops, she would be able to increase her income up to 40,000 or 80,000 Riel per day. The practice of crop diversification enables her to generate an income on a daily basis.

Crop diversification with the rotation of the crop in each row after the harvest could assist in reducing soil degradation. According to her experience and observations each crop absorbs different nutrients from the soil. If one row is repeatedly used to cultivate spring onions, they tend not to flourish so well and the roots have a tendency to decay. However if they are rotated with another crop and the spring onions are then grown in another row, they are able to thrive and the roots and stems are less likely to spoil. Crop diversification also has other functions as the cover crops help to reduce soil degradation through expose to sunlight, maintain soil moisture, make the soil less compact and add beneficial micro-organisms to the soil. In addition crop diversification

LOCATION

Location: Ruessei Duoch village, Banteay Peal Commune, Rolea B'ier District, Kampong Chhnang Province., Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites
- 104.53089, 12.25709

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 10-50 years ago

Type of introduction
☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☑ during experiments/ research
☑ through projects/ external interventions

can control pests especially the practice of growing companion plants such as herbs or spring onions as this can prevent crops from being damaged by pests.

The use of this technology assists in improving livelihoods, reduces migration because she does not need to move in order to find a job in another location, and enables her to generate a daily income. In addition this technology is able to reduce the risk of crop failure resulting from damage by pests and insects.Furthermore it reduces the risks associated with changes in market demand as the farmer produces a diversity of crops and also it prevents and reduces soil degradation. In order to effectively use this technology there needs to be sufficient water supply such as a river, stream, well or pond.This enables the land user to grow crops throughout the year round and reduces damage of crops as the result of unpredictable adverse climate conditions such as changes in rainfall, or the occurrence of drought.


Anise basil (Mr. Sok Pheak)


Spring onion (Mr. Sok Pheak)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use

Cropland - Annual cropping
Main crops (cash and food crops): Spring onion, anise basil, Cambodian mint, bok choy, escarole, choy sum, mint, long bean, cucumber, bitter melon, lettuce.

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 3

Land use before implementation of the Technology: Degraded forest land.

Livestock density: n.a.

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

physical soil deterioration - Pc: compaction

biological degradation - Bc: reduction of vegetation cover, Bs: quality and species composition/ diversity decline, Bl: loss of soil life, Bp: increase of pests/ diseases, loss of predators

SLM group

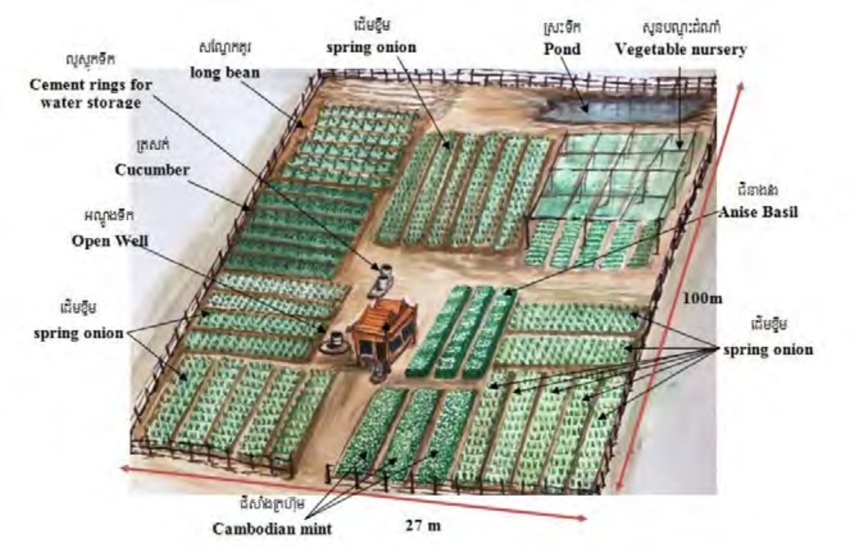
- rotational systems (crop rotation, fallows, shifting cultivation)
- integrated soil fertility management
- integrated pest and disease management (incl. organic agriculture)

SLM measures

agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility

structural measures - S5: Dams, pans, ponds other measures -

TECHNICAL DRAWING



Author: Mr. Khoun Sophal

Technical specifications

The total area on which the technology has been applied amounts to 2700 square meters (27 meters x 100 meters). Each of the diverse crop species such as spring onions, anise basil, bok choy, choy sum, escarole, Cambodian mint, long beans, bitter melons and lettuce have been divided into separate blocks.

The spring onion crop has been divided into 5 blocks out of which the first block measures 8.50 m x 8.50 m = 72.25 square meters and it contains a total of five rows. The length of each row is 8.50 m and width is 1.4 m and space between each row is 4 centimeters. The second block measures 14.60 m x 13 m= 189.3 square meters and it has been divided into two rows. Each row is 14.60 m in length and has a width of 1.4 m with a space of 4cm between the two rows. The third block measures 9.60 m x 3.90 m= 37.44 square meters and it contains 6 rows. Each of the rows is 9.60 m x 1.4 m and the space between each of the rows is 4 cm. The fourth block measures 6.35 m x 4.55 m= 28.89 square meters and it is divided into 4 rows. Each of the rows is 6.35 m in length and 1.4 m in width, and the space between each of the rows is 4 cm. The fifth block measures 11.60 m x 14.70 m = 170.52 square meters and it contains 6 rows. Each of the rows is 11.60 m in length, and 1.5 m in width and the space between each of the rows is 4 cm.

The block in which the anise basil is grown is 14.60 meters in length and 1.4 meters in width with a 4 cm space between the 3 rows. The block of cucumbers is divided into 6 rows with the length of each row being 10 meters and the width being0.5 meters. Each row rises to a height of about 1.5 cm and within the row the space between each cucumber clump is 0.5 cm. In the block of the long beans there are 6 rows with each row being 10 meters in length and 0.5 meters in width. Additionally the height of each row is 1.5 cm and space between each clump of long beans is 2 cm.

The nursery containing escarole, choy sum and lettuce is 14.60 meters x 13.50 meters and its roof has a height of 2 meters. There are two cement rings which also have a cement base that have been constructed for water storage. Each cement ring is 1 meter in height and 1 meter in diameter. Furthermore there is also one open well and a pond which provide water for domestic supply and the irrigation of crops.

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **2700 square meters**; conversion factor to one hectare: **1 ha =**)
- Currency used for cost calculation: **KHR**
- Exchange rate (to USD): 1 USD = 4000.0 KHR
- Average wage cost of hired labour per day: 15000

Most important factors affecting the costs

Cow manure, chicken manure, rice husk, botanical pesticides has to be bought. Digging the pond and buying the water pumping machine are the most important factors affecting the costs. However these equipments are longlasting.

Establishment activities

1. Dig open well (Timing/ frequency: During dry season)
2. Dig pond (Timing/ frequency: During dry season)
3. Plough the soil two times and dry the soil by sunlight (Timing/ frequency: After harvest)
4. Buy crop seeds (Timing/ frequency: At the beginning of soil preparation)
5. Prepare pipe lines into cement rings (Timing/ frequency: At the beginning of soil preparation)
6. Buy net to cover the roof of the nursery house (Timing/ frequency: At the beginning of soil preparation)
7. Buy materials such as spit, handled basket, hoe ect (Timing/ frequency: At the beginning of soil preparation)

Establishment inputs and costs (per 2700 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
Plough the soil for the first and second time	person-day	11.0	15000.0	165000.0	100.0
Clear land for growing 11 different crops	person-day	15.0	15000.0	225000.0	100.0
Dig the open well and put the cement ring	person-day	84.0	15000.0	1260000.0	100.0
Dig pond	person-day	133.0	15000.0	1995000.0	100.0
Equipment					
Bamboo sticks	Piece	50.0	1500.0	75000.0	100.0
Hoe	Piece	2.0	17000.0	34000.0	100.0
Spit	Piece	2.0	1300.0	2600.0	100.0
Handle basket to carry soil	Pair	1.0	6000.0	6000.0	100.0
Plant material					
Spring onion	Kilogram	10.0	1000.0	10000.0	100.0
Bok choy	Can	12.0	1500.0	18000.0	100.0
Escarole	Package	2.0	10000.0	20000.0	100.0
Choy Sum	Can	5.0	1500.0	7500.0	100.0
Anise basile	Package	1.0	15000.0	15000.0	100.0
Mint	Kilogram	3.0	4000.0	12000.0	100.0
Cambodian mint	Kilogram	2.0	2500.0	5000.0	100.0
Long bean	Kilogram	1.0	60000.0	60000.0	100.0
Fertilizers and biocides					
Buy cow manure for the use of one year	Two wheel handle tractor	10.0	70000.0	700000.0	100.0
Buy chicken manure for the use of one year	Bag	20.0	4000.0	80000.0	100.0
Buy soil of termite mounds	Two wheel handle tractor	10.0	40000.0	400000.0	100.0
Buy botanical pesticides	Liter	6.0	4000.0	24000.0	100.0
Rice husk	Bag	30.0	1500.0	45000.0	100.0
Buy Bat manure for soil preparation	Bag	5.0	70000.0	350000.0	100.0
Construction material					
Water Pumping Machine	Piece	2.0	880000.0	1760000.0	100.0
Cement rings which also have a cement base that have been constructed for water storage to irrigate crops.	Piece	2.0	70000.0	140000.0	100.0
Net for making the roof to prevent sunlight and water.	Set	2.0	220000.0	440000.0	100.0
Other					
Cucumber	Can	1.0	40000.0	40000.0	100.0
Lettuce	Package	5.0	15000.0	75000.0	100.0
Bitter melon	Package	2.0	5000.0	10000.0	100.0
Total costs for establishment of the Technology				**7974100.0**	

Maintenance activities

1. Watering (Timing/ frequency: Two times per day or three times per day depend on the weather.)
2. Apply cow manure (Timing/ frequency: When dig the soil near the crop root.)
3. Apply bat manure (Timing/ frequency: When dig the soil near the crop root.)
4. Weeding (Timing/ frequency: Once a week)
5. Spraying pesticides (Timing/ frequency: When there is insects.)

Maintenance inputs and costs (per 2700 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
When weeding, dig the soil near the crop root and apply fertilizer for elevent diversify of crops.	Person-day	12.0	15000.0	180000.0	100.0
Spray pesticides	Person-day	3.0	15000.0	45000.0	100.0
Equipment					
Diesel	liter	10.0	3000.0	30000.0	100.0
Fertilizers and biocides					
Liquid fertilizer made of bat manure buying from fertilizer company.	liter	1.0	70000.0	70000.0	100.0
Total costs for maintenance of the Technology				**325000.0**	

NATURAL ENVIRONMENT

Average annual rainfall

☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☑ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone

☐ humid
☑ sub-humid
☐ semi-arid
☐ arid

Specifications on climate

Average annual rainfall in mm: 1209.0
The annual rainfall in 2015 is 1209 mm. In 2014 is 1420.74 mm and in 2013 is 1367.5 mm
Name of the meteorological station: Ministry of water resources and meteorology, 2015
There are two seasons: Rainy season and dry season.

Slope
☐ flat (0-2%)
☑ gentle (3-5%)
☐ moderate (6-10%)
☐ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☑ 0-100 m a.s.l.
☐ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☐ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☑ very deep (> 120 cm)

Soil texture (topsoil)
☑ coarse/ light (sandy)
☐ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☑ medium (1-3%)
☐ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☑ good
☐ medium
☐ poor/ none

Water quality (untreated)
☑ good drinking water
☐ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☐ high
☑ medium
☐ low

Habitat diversity
☐ high
☑ medium
☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☐ mixed (subsistence/ commercial
☑ commercial/ market

Off-farm income
☐ less than 10% of all income
☑ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
☐ poor
☑ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☐ animal traction
☑ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☑ women
☐ men

Age
☐ children
☐ youth
☐ middle-aged
☑ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☑ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☐ small-scale
☑ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor	☐	☐	☑	good
education	poor	☐	☐	☑	good
technical assistance	poor	☑	☐	☐	good
employment (e.g. off-farm)	poor	☐	☐	☑	good
markets	poor	☐	☐	☑	good
energy	poor	☑	☐	☐	good
roads and transport	poor	☐	☐	☑	good
drinking water and sanitation	poor	☐	☐	☑	good
financial services	poor	☐	☐	☑	good

IMPACTS

Socio-economic impacts

Crop production	decreased	☐	☐	☐	☐	☐	☑	☐	increased

The crop diversification and the subsequent cultivation of vegetables and herbs during the whole year, as well as the distinct crop rotational plan increased considerably her crop production.

crop quality	decreased	□□□□□✓□	increased	The application of natural fertilizers and botanical pesticides, as well as the method of crop rotation and selection of companion plants led to better crop quality.
risk of production failure	increased	□□□□□✓□	decreased	Due to the permanent soil cover, the high crop diversification and the sophisticated pest control the risk of production failure decreased.
demand for irrigation water	increased	□□□□✓□□	decreased	The plantation of a large variety of vegetables and herbs all year round let to higher irrigation water demand especially during the dry season or at drought events.
expenses on agricultural inputs	increased	□✓□□□□□	decreased	The crop diversification requires a lot of monetary inputs mainly for the establishment and also for the maintenance (labor for digging the pond, water pumping machine, natural fertilizers has to be bought - she does not raise animals).
farm income	decreased	□□□□□✓□	increased	Although the land user had to invest a lot of money for this technology, she got and get still better and regular daily income from the sale of the wide range of different crops at the market compared to what she earned before. All in all she was able to improve the household's livelihood.
workload	increased	□✓□□□□□	decreased	This technology is sophisticated and rather time consuming compared to conventional growing methods (mono-cropping of cassava for example). In this case study the land user invests only her own and her husband's labor force.
Socio-cultural impacts				
food security/ self-sufficiency	reduced	□□□□□✓□	improved	The self sufficiency increased as she gets every day her own vegetables from the vegetable plot. And at a daily base she gets money from the sale of her vegetables to meet all needs of the household. Further, she was able to reduce the risk of crop failure which increased the food security.
health situation	worsened	□□□□□✓□	improved	The health situation of the farmer and her husband were improved as the production is near to be fully organic very low use of chemical pesticides/biocides. And by the health production she supports also the health of the other consumers.
SLM/ land degradation knowledge	reduced	□□□□□✓□	improved	The land user got a broad knowledge about the crop diversification and crop rotation technology. Mainly regarding the reduction of chemical soil degradation and regarding how to support better plant growth.
Ecological impacts				
water quality	decreased	□□□□□✓□	increased	Due to very low application of chemical pesticides.
evaporation	increased	□□□□□✓□	decreased	Due to the improved soil cover by the different vegetables and herbs all year long the evaporation deceased.
soil moisture	decreased	□□□□□✓□	increased	Soil moisture increased due to the improved soil cover that could reduce evaporation into environment.
soil compaction	increased	□□□□□✓□	reduced	The soil compaction is less due to better soil moisture, crop rotation and using natural fertilizers.
soil organic matter/ below ground C	decreased	□□□□□✓□	increased	The soil organic matter increased due to the application of natural fertilizers.
vegetation cover	decreased	□□□□□✓□	increased	All year long the soil is covered by different vegetables and herbs.
plant diversity	decreased	□□□□□✓□	increased	Before she has cultivated only one crop on the area but she grows now eleven different vegetables and herbs.
beneficial species (predators, earthworms, pollinators)	decreased	□□□□□✓□	increased	The soil life increased regarding bacteria and fungi,

				earthworm, ant, and centipede due to the crop rotation system and the use of natural fertilizers and botanical pesticides.
habitat diversity	decreased	☐☐☐☐☐✓☐	increased	The nearly organic cultivation provides a habitat for a large variety of soil organisms such as earthworm, termites or ants.
pest/ disease control	decreased	☐☐☐☐☐✓☐	increased	The pest and disease control is improved due to the rotational system, the use of botanical pesticides, and the cultivation of companion plants such as anise basil, Cambodian mint and spring onions.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes			
Gradual climate change				
annual temperature decrease	not well at all	☐☐☐✓☐	very well	
seasonal temperature decrease	not well at all	☐☐☐✓☐	very well	Season: wet/ rainy season
seasonal temperature increase	not well at all	☐☐☐✓☐	very well	Season: dry season
annual rainfall decrease	not well at all	☐☐☐✓☐	very well	
seasonal rainfall decrease	not well at all	☐☐☐✓☐	very well	Season: wet/ rainy season
Climate-related extremes (disasters)				
drought	not well at all	☐☐☐✓☐	very well	
epidemic diseases	not well at all	☐☐✓☐☐	very well	
insect/ worm infestation	not well at all	☐☐☐✓☐	very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☐ 1-10%
☑ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Number of households and/ or area covered

7 families

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Provides a daily income.
- The quality of the soil is better through crop rotation and the exchange of crops in the rows. Additionally cow manure and soil from the termite mound can be used as fertilizer.
- The actual work can be done by oneself which involves physical exercise and is good for one's health.

Strengths: compiler's or other key resource person's view

- Grow a diversity of crops which reduces the risk of production failure from damaging from insects, disease and market.
- The farmer is able to generate a daily income, thereby improving her livelihood and it gives her the means to cope

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- During some months it is not possible to grow herbage vegetables. → Can grow other crops such as anise basil.
- She has to water the crops only by herself which is very exhausting → Must try harder.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- Farmer spends a lot of time for watering the crops. → Could change and start using a sprinkler or drip irrigation system in order to reduce labor.
- Must properly record expenses and income so as to verify the

with her daily expenses.
- Crop rotation could reduce soil degradation.
- Reduces migration as now she has her own job and as this technology improves her livelihood.

net income. → Provide training in recording income and expenses.

REFERENCES

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Date of documentation: Aug. 22, 2017

Last update: April 25, 2018

Resource persons
Thon Phrum (N/A) - land user
Bunleang Chhim (chhimbunleang@gmail.com) - Vice Chief of Agronomy Office at Agricultural Office of Rolea B'ier
Sombo Khim (khimsombo79@gmail.com) - Vice Chief of Agricultural Extension Office at Provincial Department of Agriculture, Forestry and Fisheries, Kampong Chhnang province
Se Keo (keo.se2017@gmail.com) - Chief of Agricultural Office of Tuek Phos

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_3145/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

Links to relevant information which is available online

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Growing pok choi and escarole inside the nethouse (Mr. Kim Soben)

Growing vegetables in a nethouse to ward off insects (Cambodia)

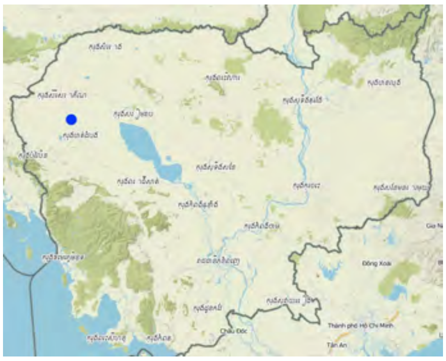
Nethouse

DESCRIPTION

A nethouse is a structure that is enclosed by a nylon net (like mosquito nets) which protects vegetables from insects. Additionally, it prevents the vegetables from being damaged by rainfall wind and sunlight.

Currently one of the major challenges farmer face when growing vegetables is the damage caused by insects. Moreover, climate change creates obstacles when cultivating crops such as irregular rainfall, strong winds, and a rise in temperature. In order to address these issues the farmers trialed the growing of vegetables under a nethouse. Nethouses also enable crop growing throughout the whole year.
The main purpose of building a nethouse is to ward off insects without having to apply pesticides. A nethouse is highly effective in damage reduction caused by insects on crop from 80% to 100% (Stilers, 2011). Also farmers noticed that there's no significant insect infestation when using this technology. The netted roof helps to protect vegetables from direct rainfall onto them as this can damage plants or splashes soil on plant's leaves. As well it is slowing down the speed of rainfall and split it into small droplets, which is important to improve the cultivation of vegetables during rainy season, (usually farmer can grow vegetables only during dry season).
Nethouses come in a range of different size and height, and construction materials also differ depending on the available resources. Before setting up a nethouse, farmer will firstly have to prepare the terrain and then mark out the points where posts will be installed (generally it is rectangular in shape) and dig holes measuring 0.40 meters x 0.40 meters with a depth of 1 meter at all of the marked out point. After post have been inserted into these holes they should be filled with concrete to a height of 60 cm so as to secure post (the length of side post are 3 meters and the middle post are 4 meters). After frame completion, nylon ropes are extended. They act as frames to support the net and then lastly, the net is rolled over the frame to cover the entire nethouse (the sides of net should be buried in ground at a depth of 25 cm). There are two common types of nethouse roofs, those being either a gable roof or a curved (gambrel) roof, which is better than a flat roof that risks breaking down when water accumulates on it during heavy rainfalls.
Farmers generally use the same cultivation techniques as other farmers. The differences lie in the nethouse, in nearly no use of chemical fertilizers and in complete elimination of pesticide. The interviewed farmer established a nethouse measuring 316.25 square meters at Tasei village, Tameun commune (Thmakoul district). The land selected by the farmer for such nethouse vegetable growing was previously a rice field. He considered that rice can only be grown once a year, whereas vegetables can be grown throughout the year. Thus, it is possible to generate more income. They decided to dig a large pond (35meter x 35meter) for water storage connected to the irrigation system, which disburden him from watering during dry season. Initially, the excavated soil was less fertile, but the farmer used compost for one year, after which it was possible to improve the soil quality. The farmer makes dry and liquid compost by himself and also uses organic fertilizer which is purchased externally. The liquid compost is made up of sugar palm 1 kg, pineapple 5 kg and coconut juice 2 liters. This practice adds nutrients to soil and promotes a lot of living organisms that make crops flourish.
Comparing the construction costs and time it takes to make a profit from sale of

LOCATION



Location: The farm behind the village, Ta Sei village, Ta Meun commune, Thmakoul district, Battambang province., Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 103.08678, 13.29038

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 2017

Type of introduction

☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☑ through projects/ external interventions

vegetables farmers have to have at least three harvests before they can cover the cost of the nethouse or to achieve the profit. The nethouse can be used for a period of 10 to 13 years, and it is only necessary to change the nylon net once it is ripped. The actual gross income from pok choi and escarole is 1,590,000 riels for 530 kilograms.
If he continued to produce rice on this land, this would generate 100kg of rice sold at about 800 riels per kg and so, he would gain 80,000 riels per year. However, as the farmer applies this technology he can grow vegetable several times per year (6-7 times) with an average yield of 530 kg per harvest that amounts to 3,180 kg per year. If one kilogram of vegetables is worth 3000 riel he is able to generate an income of around 9,540,000 riel, which is more than hundredfold that of rice. Additionally, he is able to produce safe vegetables, contributes to the reduction in environmental pollution and the technology is adapted to climate change.

The nethouse protects vegetables from insects (Mr. Kim Soben)

Overview of nethouse from the outside (Mr. Kim Soben)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☐ conserve ecosystem
☑ protect a watershed/ downstream areas – in combination with other Technologies
☑ preserve/ improve biodiversity
☐ reduce risk of disasters
☑ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact
☑ improve consumers health

Land use

Cropland - Annual cropping
other (specify): Short-term crop
Main crops (cash and food crops): Pok choi, escarole, choy sum, cabbage in rotation during one year

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 3

Land use before implementation of the Technology: It used to be the paddy field before but it just changed to vegetable growing last year (2017).

Livestock density: N/A

Purpose related to land degradation

☑ prevent land degradation
☐ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion

chemical soil deterioration - Cp: soil pollution

biological degradation - Bl: loss of soil life, Bp: increase of pests/ diseases, loss of predators

water degradation - Ha: aridification

SLM group

- rotational systems (crop rotation, fallows, shifting cultivation)
- improved ground/ vegetation cover
- integrated pest and disease management (incl. organic agriculture)

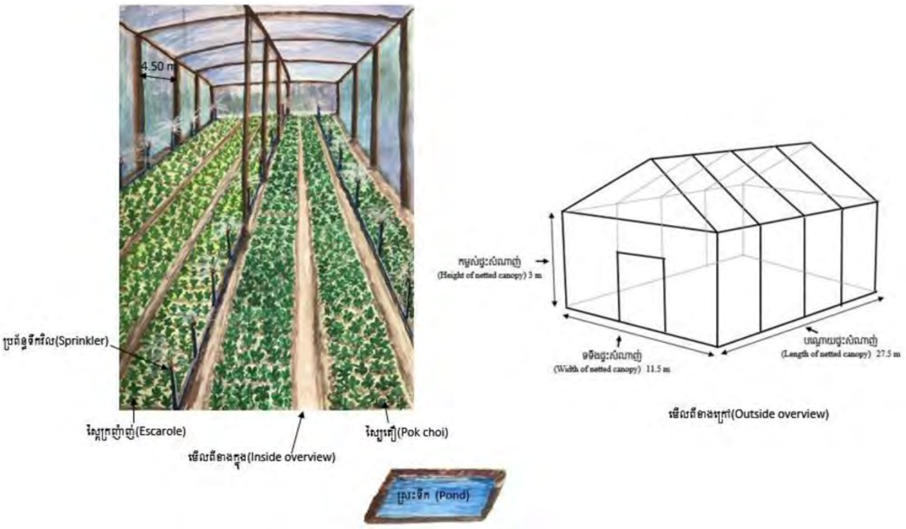
SLM measures

agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility

TECHNICAL DRAWING

Technical specifications

The nethouse is 27.50 meters x 11.50 meters, with 3 meters high. It uses 18 wooden pillars with a space of 4.50 meters from to another. Inside the nethouse, there are 6 rows of vegetable and each row has 9 sprinkler heads for the irrigation. Actually, the farmer planed 2 types of crop - pok choi and escarole. The ways between the vegetable rows are about 45 centimeters in width.



Author: Mr. Khoun Sophal and Ms. Lay Nary

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **316.25 square meters**)
- Currency used for cost calculation: **KHR**
- Exchange rate (to USD): 1 USD = 4000.0 KHR
- Average wage cost of hired labour per day: 28000

Most important factors affecting the costs

Nylon netting and pillars

Establishment activities

1. Prepare the land (Timing/ frequency: June)
2. Make the pillars for the nethouse (Timing/ frequency: June)
3. Make the roof and the surrounding with the nylon netting (Timing/ frequency: June)
4. Plow the land again (Timing/ frequency: June)
5. Make the row and prepare sprinkler system (Timing/ frequency: June)
6. Irrigation and planting (Timing/ frequency: July)

Establishment inputs and costs (per 316.25 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
Prepare and plowing the soil	person-day	1.0	28000.0	28000.0	100.0
Set up nethouse	person-day	1.0	28000.0	28000.0	100.0
Equipment					
Rotary machine	Set	1.0	3000000.0	3000000.0	100.0
Pumping machine	Piece	1.0	420000.0	420000.0	100.0
Pipe	stem	8.0	20000.0	160000.0	100.0
Plant material					
Pok choi seed	cans	1.0	7000.0	7000.0	100.0
Escarole seed	cans	1.0	4500.0	4500.0	100.0
Fertilizers and biocides					
Cow manure	bag	10.0	10000.0	100000.0	100.0
Construction material					
wooden pole	stem	28.0	8000.0	224000.0	100.0
Pillars 3 meters in height	stem	16.0	25000.0	400000.0	100.0
Pillars 4 meters in height	stem	7.0	35000.0	245000.0	100.0
Nylon nettings	set	2.0	1200000.0	2400000.0	
Cement	bag	2.0	20000.0	40000.0	100.0
Sand	cubic	0.5	30000.0	15000.0	100.0
Rock	cubic	0.5	30000.0	15000.0	100.0
Nail at size of 12 cm	package	2.0	5000.0	10000.0	100.0
Other					
Nail at size of 10 cm	package	2.0	5000.0	10000.0	100.0
Shovel	Piece	1.0	12000.0	12000.0	100.0
Rake	Piece	1.0	35000.0	35000.0	100.0
Sprinkler	set	1.0	450000.0	450000.0	100.0
Nylon	kilogram	5.0	13000.0	65000.0	100.0
Black nylon	kilogram	4.0	5000.0	20000.0	100.0
Total costs for establishment of the Technology				**7688500.0**	

Maintenance activities
1. Irrigation (Timing/ frequency: every day)
2. Spaying liquid compost (Timing/ frequency: once week per month)
3. Weeding and thinning cabbage seedlings (Timing/ frequency: at 15 days old, weeding and thinning cabbage seedlings)

Maintenance inputs and costs (per 316.25 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
Weeding and thinning cabbage seedlings	person-day	1.25	28000.0	35000.0	100.0
Spray liquid compost (by himself)	person-day	6.0	28000.0	168000.0	100.0
Equipment					
Spraying tank	set	1.0	60000.0	60000.0	100.0
Plant material					
Fertilizer (N P K)	Kilogram	6.0	2000.0	12000.0	100.0
Fertilizer (A D P)	Kilogram	1.0	2500.0	2500.0	100.0
Other					
Gasoline for pump water one cycle of cropping	liter	6.0	3200.0	19200.0	100.0
Total costs for maintenance of the Technology				**296700.0**	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate
Average annual rainfall in mm: 1102.02
The annual rainfall in 2015 is 1102.02 mm. In 2014 is 878.13 mm and in 2013 is 1393 mm.
Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)
There are 2 seasons, dry season and raining season (during the rainy season, there is mini-drought which takes from July or August).

Slope
- ☑ flat (0-2%)
- ☐ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☑ plateau/plains
- ☐ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☑ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Soil depth
☐ very shallow (0-20 cm)
☐ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☑ very deep (> 120 cm)

Soil texture (topsoil)
☐ coarse/ light (sandy)
☐ medium (loamy, silty)
☑ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☐ medium (1-3%)
☑ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
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☐ poor/ none

Water quality (untreated)
☑ good drinking water
☐ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

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☑ low

Habitat diversity
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☐ subsistence (self-supply)
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☐ Semi-nomadic
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Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☐ women
☑ men

Age
☐ children
☐ youth
☑ middle-aged
☐ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☑ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☐ small-scale
☑ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor	✓			good
education	poor		✓		good
technical assistance	poor			✓	good
employment (e.g. off-farm)	poor		✓		good
markets	poor	✓			good
energy	poor		✓		good
roads and transport	poor			✓	good
drinking water and sanitation	poor			✓	good
financial services	poor		✓		good

IMPACTS

Socio-economic impacts

Crop production	decreased						✓		increased	Before only rice was growing on the field but now the farmer cultivates it with many vegetables such as pok choi, escarole, choy sum.
crop quality	decreased						✓		increased	He does not use chemical pesticides, but he has a efficient protection against pest due to the nethouse and also he uses compost that makes the soil rich in nutrients for good plant growth.
risk of production failure	increased							✓	decreased	There are no more damages by insects or rainfall.
product diversity	decreased						✓		increased	Now the farmer is able to grow many different

vegetables which can be harvested more than 6 to 7 times a year.

land management	hindered							✓	simplified	Planting difference crops and apply of rotation technique use the varying availability soil nutrients. Application of compost and cow manure could improve soil quality. Anyway, growing crop in nethouse to ward off insect and stop use chemical pesticide simplify the land management.
irrigation water availability	decreased					✓			increased	The new pond has enough water for irrigation.
demand for irrigation water	increased					✓			decreased	Use sprinkler for irrigation.
expenses on agricultural inputs	increased			✓					decreased	Cost of the nethouse at the beginning is very high.
farm income	decreased						✓		increased	Do not spend money to buy chemical pesticide and can grow many times during the course of the year.
workload	increased							✓	decreased	Not require labor for watering as before.

Socio-cultural impacts

food security/ self-sufficiency	reduced							✓	improved	He cultivates many crops and at many times. In consequence the food security and self-sufficiency increased.
health situation	worsened							✓	improved	As the farmer uses no chemical pesticides, the production of the vegetable is very healthy for consumers.
community institutions	weakened							✓	strengthened	The farmer can get information and share experience in an association for organic vegetable growing.
national institutions	weakened							✓	strengthened	There are trainings by official government at province level and other projects as Safe Vegetable Value Chain in Cambodia project.
SLM/ land degradation knowledge	reduced							✓	improved	Using nethouse for growing vegetable, which prevents from insects invasion and making dry and liquid compost.

Ecological impacts

harvesting/ collection of water (runoff, dew, snow, etc)	reduced					✓			improved	He digged a pond for the irrigation system near the nethouse in case of drought and during dry season.
evaporation	increased						✓		decreased	There are cover crops and nethouse which help to reduce heat and therefore evaporation.
soil moisture	decreased							✓	increased	The vegetables as a kin of cover crop keep moisture and the nethouse impede evaporation.
soil loss	increased							✓	decreased	The cover crops and as well the nethouse protect from rill erosion.
soil compaction	increased							✓	reduced	Using organic compost improved the soil. Now the soil is rich in earth worms and other organisms which prevent compaction.
soil organic matter/ below ground C	decreased							✓	increased	The soil rich in nutrition by using compost now.
invasive alien species	increased						✓		reduced	There is not damaged from insects as before.
beneficial species (predators, earthworms, pollinators)	decreased						✓		increased	There are more earth worms and beneficial species in the soil.
pest/ disease control	decreased		✓						increased	The nethouse reduces crop damages from insect very effectively.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative					✓			very positive
Long-term returns	very negative							✓	very positive

Benefits compared with maintenance costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative						✓		very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed

How the Technology copes with these changes/extremes

Gradual climate change

annual temperature increase	not well at all				✓		very well	
seasonal temperature increase	not well at all				✓		very well	Season: wet/ rainy season
annual rainfall increase	not well at all				✓		very well	

Climate-related extremes (disasters)

drought	not well at all					✓	very well
epidemic diseases	not well at all					✓	very well
insect/ worm infestation	not well at all					✓	very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Number of households and/ or area covered

6 families

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- No use of chemical pesticides.
- Able to cultivate numerous crops almost throughout the whole year.
- Produce safe vegetables.
- Increase income.

Strengths: compiler's or other key resource person's view

- Good adaptation to climate change by maintaining a good soil moisture, less use of water and a good protection of the vegetables from being damaged by heavy rainfall.
- No use of pesticides, creates a low demand for fertilizer and helps to reduce the expenditure on fertilizer. The technology is easy to manage, maintain and control.
- Production of safe vegetables for consumption.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Generates heat and there is less air circulation. → Utilize a fan.
- It is not easy to go in and out of the nethouse. → Construct a proper door.
- Have to spend a lot of money to construct the nethouse. → Progress as resources are available such as bamboo, small wood in forests.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- Have to spend a lot of money to make the nethouse. → Finding partners or organizations to corporate. Farmer could make nethouse by other resources available like bamboo or small wood.
- In nethouse is less air circulation. → Utilize a fan.

REFERENCES

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Date of documentation: Aug. 18, 2017

Last update: April 30, 2018

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_3138/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

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Intercropping and use of net roof (Mr. Kim Soben)

Intercropping of vegetables to control pests along the Mekong river bank (Cambodia)

Natural Vegetable

DESCRIPTION

Cropping by setting up alternative rows of different crops: lettuce, pak choi, escarole, choy sum and morning glory for a reduction in damage from insects. This technique incorporates the spreading of lime in advance for control of soil pests, and plant derived pesticide is applied during the cultivation period. This technique is applied on the Mekong river bank in Kratie province.

Intercropping is a technique of cropping in which two or more crops are grown in different alternate rows at the same time (Pawan et al., 2012). The crops grown by the farmers are lettuce, pak choi, choy sum, escarole and morning glory. This technique was applied using 1080 square meters of land along the Mekong's river bank in Kratie province. In applying this technique, the farmer prepared the land, after which he prepared the rows across the slope of the river bank. Lettuce was planted in the first row, then pak choi, choy sum, escarole, and then morning glory, with the crop sequence being repeated in the following rows. Intercropping helps to reduce the damage from insects. Lettuce is a crop that insects dislike because of its bitter taste. Under the intercropping practice with the vegetables that insects dislike, the level of insect damage is reduced because, when facing such repellent crops, the insects normally disappear rather than go to the next row, even though it might be a crop they like.

Crops are easily damaged by insects when grown as a single species that insects like. In intercropping, even if the insects damage one crop, the other crops often survive without insect damage. To apply this technology more effectively, farmer used botanical pesticide that was produced by the farmer himself based on plant ingredients such as neem bark, boraphed, strychnine plant, derris, etc. Such natural pesticide ingredients are crushed and soaked in water for 15 days, after which l liter is mixed with 15 liters of water(Yang et al., 2006). The solution is sprayed on the crops on a daily basis when insects are present.

Soil preparation: The soil is ploughed and dried for 7 to 8 days, then aligned into rows with lime being applied for a period of 6 days to disperse the bad bacteria in the soil. Nursery preparation of escarole, pak choi and choy sum takes about 20 days before transplanting (morning glory was planted by direct seeding). Lettuce is only 10 days old when it is transplanted. Lettuce can be harvested within 30 days after transplanting, while morning glory is grown for about 38 days before being harvested. The farmer used organic fertilizer and cow manure to improve the soil fertility. The farmer makes the rows across the slope of the river to prevent soil erosion during heavy rainfall. To provide protection from the potential adverse effects of direct sunlight and rain, the farmer used a temporary 2 meters high net roof supported by bamboo poles, to provide cover. A net fence was also constructed around the crop area to provide protection from animals such as dogs and chickens. In relation to produce price, pak choi returned 3.500 to 4.000 riel per kilogram, morning glory 2.000 riels per kilogram, choy sum 2.000 to 3.000 riel per kilogram, escarole 3.000 to 3.500 riel per kilogram and lettuce 4.000 riel per kilogram.

LOCATION

Location: Land is along Mekong River, Ta Mau Leu village, Kampong Kor Commune, Preaek Prasab District, Kratie Province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites
- 105.94759, 12.27654

Spread of the Technology: applied at specific points/ concentrated on a small area

Date of implementation: less than 10 years ago (recently)

Type of introduction

☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☐ through projects/ external interventions

Overview of intercropping along the Mekong River bank (Mr. Kim Soben)

Intercropping by using net to protect rain and sunlight (Mr. Kim Soben)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☐ improve production
☑ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact
☑ Reduce soil erosion by making rows across the slope, prevent crops' exposure to sunlight and rain, reduce insects

Land use

Cropland - Annual cropping
Main crops (cash and food crops): Lettuce, pok choi, choy sum, escarole and morning glory

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 3
Land use before implementation of the Technology: Before the farmer did intercropping and crop rotation he only grew onion.
Livestock density: No livestock

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

soil erosion by water - Wr: riverbank erosion

physical soil deterioration - Pu: loss of bio-productive function due to other activities

biological degradation - Bp: increase of pests/ diseases, loss of predators

SLM group

- rotational systems (crop rotation, fallows, shifting cultivation)
- integrated soil fertility management
- integrated pest and disease management (incl. organic agriculture)

SLM measures

agronomic measures - A2: Organic matter/ soil fertility

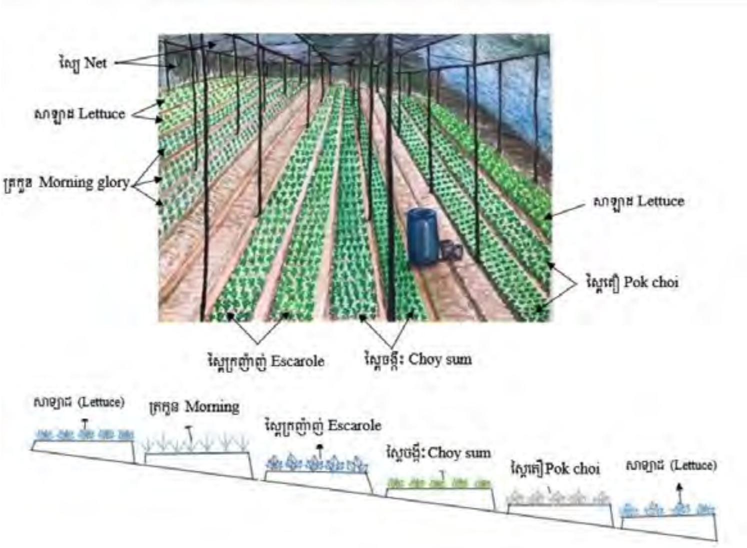
structural measures - S4: Level ditches, pits, S9: Shelters for plants and animals

management measures - M5: Control/ change of species composition

TECHNICAL DRAWING

Technical specifications

The farmer prepared the rows for cropping using a soil height of 15 cm, 1.20 meters width and 30 meter length, with the rows being across the slope to the river to prevent soil erosion during heavy rainfall. He planted lettuce, pok choi, escarole, morning glory and choy sum in alternate rows to protect the crops from insect damage. The planting house constructed was 2 meters in height, with netting being used as a roof to provide protection against direct sunlight and rainfall. The materials used comprised three rolls of nets, 26 bamboo poles for a protective roof, and five rolls of nets for the construction of a protective border fence. The materials for irrigation include a bucket for irrigating seedlings and a hoose with a length of 700 meters used with a pumping machine for irrigation.



Author: Mr. Khoun Sophal and Ms. Lay Nary

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **1080 square meters**)
- Currency used for cost calculation: **KHR**
- Exchange rate (to USD): 1 USD = 4000.0 KHR
- Average wage cost of hired labour per day: 17,000

Most important factors affecting the costs

The price of fertilizer and seeds depends on type of seed and market price.

Establishment activities

1. Rent soil for cultivating vegetables (Timing/ frequency: November)
2. Prepare soil (plow and dry soil, make row and spread the lime) (Timing/ frequency: December)
3. Material for building (net, pole of bamboo, tank and plastict bowl) (Timing/ frequency: when cultivation)
4. Seeds (Timing/ frequency: when cultivation)
5. Organic and manure fertilizer (Timing/ frequency: when cultivation and maintenance)

Establishment inputs and costs (per 1080 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
Prepare soil	person-day	3.0	17000.0	51000.0	100.0
Equipment					
Pumping machine	set	1.0	1000000.0	1000000.0	100.0
Hoe	piece	1.0	13000.0	13000.0	100.0
Rake	piece	1.0	15000.0	15000.0	100.0
Hose	piece	14.0	16000.0	224000.0	100.0
Big basket	pair	1.0	50000.0	50000.0	100.0
Plant material					
Seed of lettuce	package	15.0	10000.0	150000.0	100.0
Choy sum	package	15.0	6000.0	90000.0	100.0
Escarole	package	6.0	6000.0	36000.0	100.0
Morning glory	kilogram	14.0	10000.0	140000.0	100.0
Pok Choi	Can	2.0	7000.0	14000.0	100.0
Fertilizers and biocides					
Lime	kilogram	2.0	2500.0	5000.0	100.0
Organic fertilizer	sack	1.0	130000.0	130000.0	100.0
Construction material					
Net	piece	3.0	260000.0	780000.0	100.0
water tank	pair	1.0	50000.0	50000.0	100.0
Big plastic bowl	piece	3.0	10000.0	30000.0	100.0
storage tank	piece	1.0	80000.0	80000.0	100.0
Nylon net for the construction for a protective border fence.	piece	3.0	58000.0	174000.0	100.0
Other					
Rent land	year	1.0	300000.0	300000.0	100.0
Bamboo	pole	20.0	4000.0	80000.0	100.0
Total costs for establishment of the Technology				3412000.0	

Maintenance activities

1. Weeding, prepare soil and put fertilizer (Timing/ frequency: When the crop is at 7 days.)
2. Irrigation (morning and evening) (Timing/ frequency: every day)
3. Spray botanical pesticide (Timing/ frequency: spread pesticide when there are insect on crop)

4. Diesel (one month 30 liters) (Timing/ frequency: Two times per day (morning and afternoon.)

Maintenance inputs and costs (per 1080 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
weeding (by farmer)	person-day	4.0	17000.0	68000.0	100.0
prepare soil and put fertilizer (by farmer)	person-day	4.0	17000.0	68000.0	100.0
Spray pesticide	person-day	12.0	17000.0	204000.0	100.0
Equipment					
Pesticide sprayer equipment use by hand	set	1.0	80000.0	80000.0	100.0
Diesel	liter	90.0	2350.0	211500.0	100.0
Total costs for maintenance of the Technology				**631500.0**	

NATURAL ENVIRONMENT

Average annual rainfall
☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☑ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone
☐ humid
☑ sub-humid
☐ semi-arid
☐ arid

Specifications on climate
Average annual rainfall in mm: 1138.2
The average annual rainfall in 2015 was 1138.2 mm, in 2014 1696.5 mm, in 2013 1661.8 mm.
Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)

Slope
☐ flat (0-2%)
☐ gentle (3-5%)
☑ moderate (6-10%)
☐ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☑ 0-100 m a.s.l.
☐ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☐ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☑ very deep (> 120 cm)

Soil texture (topsoil)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☑ high (>3%)
☐ medium (1-3%)
☐ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☑ good
☐ medium
☐ poor/ none

Water quality (untreated)
☑ good drinking water
☐ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☑ Yes
☐ No

Species diversity
☐ high
☐ medium
☑ low

Habitat diversity
☐ high
☐ medium
☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☐ mixed (subsistence/ commercial
☑ commercial/ market

Off-farm income
☑ less than 10% of all income
☐ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
☐ poor
☑ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☐ animal traction
☑ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☐ women
☑ men

Age
☐ children
☐ youth
☑ middle-aged
☐ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha

Scale
☑ small-scale
☐ medium-scale

Land ownership
☐ state
☐ company

Land use rights
☐ open access (unorganized)
☐ communal (organized)

☑ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

☐ large-scale

☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled
☑ rent

☑ leased
☑ individual

Water use rights
☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor		✓		good
education	poor			✓	good
technical assistance	poor		✓		good
employment (e.g. off-farm)	poor		✓		good
markets	poor	✓			good
energy	poor			✓	good
roads and transport	poor		✓		good
drinking water and sanitation	poor			✓	good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased						✓		increased	Before farmer grew only onion but now grows several crops.
crop quality	decreased						✓		increased	Before farmer used chemical pesticide and chemical fertilizer but now farmer uses botanical pesticide and natural fertilizer.
risk of production failure	increased						✓		decreased	The farmer does the intercropping that helps to reduce damage from insects and he also uses only botanical pesticide.
product diversity	decreased						✓		increased	Before farmer grew only onion but now farmer grows multiple crops such as Escarole, Choy sum, Pok choi, Lettuce and Morning glory.
land management	hindered						✓		simplified	Because of the intercropping and crop rotation the crops absorb different nutrients from soil. Natural fertilizer makes soil rich in nutrition.
irrigation water quality	decreased					✓			increased	There is no water pollution because no more chemical pesticide is used, he uses only botanical pesticide.
expenses on agricultural inputs	increased						✓		decreased	Before he bought chemical pesticides against insects, now he uses botanical pesticide because he can do it by himself.
farm income	decreased						✓		increased	Reducing chemical fertilizer and pesticide use and instead using natural fertilizer and botanical pesticide.
economic disparities	increased					✓			decreased	The farmer livelihood is better after practicing this technology because farmer gets more money by having more crops, there is no need to buy chemical pesticides and he has a healthy life.
workload	increased			✓					decreased	Workload is a bit increased because of different crops.

Socio-cultural impacts

food security/ self-sufficiency	reduced						✓		improved	For food security is better than before because farmer can get better income, before grew only one crop but now he changed to grow multiple crops.
health situation	worsened						✓		improved	No use of chemical pesticide which harms the health.
SLM/ land degradation knowledge	reduced						✓		improved	Farmer can made botanical pesticide by himself and uses natural fertilizer.

Ecological impacts

surface runoff	increased			✓					decreased	Flooding make loss loamy soil and increase level sedimentation at down stream by plough or ridge soil at river bank
excess water drainage	reduced			✓					improved	Use net roof and create ridge of the row across the slope of the river bank to reduce water flow.

evaporation	increased	☐☐☐☐☐✓☐	decreased	Cover crops can protect soil moisture and net roof is reducing 60% of evaporation.
soil moisture	decreased	☐☐☐☐☐✓☐	increased	The cover crops can keep good soil moisture.
soil compaction	increased	☐☐☐☐☐✓☐	reduced	Farmer uses cow manure bough from other farmers or collect at the rice field and organic fertilizer bought from the fertilizer company.
nutrient cycling/ recharge	decreased	☐☐☐☐☐✓☐	increased	In intercropping each crop and rotation techniques absorbs different nutrients and this creates a balance.
pest/ disease control	decreased	☐☐☐☐✓☐☐	increased	Reduce diamond-back moth, striped flea beetle and black cutworm.

Off-site impacts

downstream siltation	increased	☐☐✓☐☐☐☐	decreased	When the land user ploughs the soil and rakes it, some topsoil will be removed when there is rainfall. To minimize the soil surface runoff, farmer constructed the bamboo pole with the net roof and created a ridge of the row across the slope of the river bank, so the soil sediment flow is increased only very little.

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐✓☐☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

Regarding the short-term returns, the farmer spent a lot of money to buy natural or organic fertilizer because at the beginning there is the infertile soil. However, after long-term practice there is no need of much natural or organic fertilizer.

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all	☐☐☐✓☐	very well	
seasonal temperature increase	not well at all	☐☐☐✓☐	very well	Season: wet/ rainy season
annual rainfall decrease	not well at all	☐☐☐✓☐	very well	
seasonal rainfall decrease	not well at all	☐☐☐✓☐	very well	Season: wet/ rainy season
this year frequently raining, last year rarely raining	not well at all	☐☐✓☐☐	very well	

Climate-related extremes (disasters)

tropical storm	not well at all	☐✓☐☐☐	very well
heatwave	not well at all	☐☐✓☐☐	very well
extreme winter conditions	not well at all	☐✓☐☐☐	very well
drought	not well at all	☐☐☐✓☐	very well
general (river) flood	not well at all	☐☐✓☐☐	very well
flash flood	not well at all	☐☐✓☐☐	very well
epidemic diseases	not well at all	☐✓☐☐☐	very well
insect/ worm infestation	not well at all	☐☐☐✓☐	very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☑ single cases/ experimental
☐ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Has the Technology been modified recently to adapt to changing conditions?

☑ Yes
☐ No

To which changing conditions?

☐ climatic change/ extremes
☑ changing markets
☐ labour availability (e.g. due to migration)

Farmer grows crops according to the market demand, for example: The market needs lettuce in the dry season, especially in March and April, lettuce have a high price: one kilogram is 4000 to 5000 riels.

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- High income
- Preventing soil from compaction by using cow manure and organic fertilizer and reduce heat by using temporary net roof.
- Reduce the insects by diversification of crops.

Strengths: compiler's or other key resource person's view

- Improves daily income.
- Reduced the use of chemical fertilizers and pesticides.
- Helps to improve soil condition.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Still have some problems with diamond back moth and striped flea beetle. → When the spraying of the chemical pesticide brings no result, they change the type of crops and use botanical pesticide which helps to get rid of the black moth and flea beetle.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- Plough the land by the river side causes the loss of loamy soil and increases the level of sediment downstream during flood events. → Reduce plowing the soil or ridging of soil before flooding.
- Have problems with insect (diamond back moth and striped flea beetle). → Use botanical pesticide made by farmer and change cropping system.

REFERENCES

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Date of documentation: April 23, 2017

Last update: July 12, 2018

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_2098/

Linked SLM data
n.a.

Documentation was faciliated by
Institution

- Royal University of Agriculture (RUA) - Cambodia

Project

- Scaling-up SLM practices by smallholder farmers (IFAD)

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Crop rotation with long bean and luffa (Mr. Sok Pheak)

Crop rotation to promote safe vegetables (Cambodia)

Safe Vegetable

DESCRIPTION

Crop rotation is a component of integrated pest management (IPM) which can contribute to an improvement in crop production with a standardized and reduced use of chemical fertilizers and pesticides.

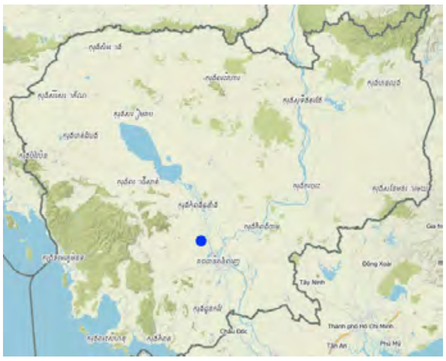
Crop rotation is the process of regularly alternating crops on a seasonal basis on the same plot of land. One of the benefits is that nutrients and nitrogen will be transferred to the soil through this practice as traditionally green manure is added when crops are alternated with cereals. The practice helps to reduce the manifestation of diseases and insects that often occur when crop cultivation is repeated over a prolonged period. Crop rotation can improve the soil's structure and fertility as different nutrients are absorbed from the soil, and the plants' root systems are able to penetrate the soil at different depths (Cotheren J., 2014). Even though Cambodia has laws regarding the application of agricultural pesticides and fertilizers there are some farmers who still use them incorrectly. As an alternative, the intercropping technology can assist farmers in increasing yields and reduce crop damage by insects, whilst maintaining and improving the soil's fertility through agronomy as well as biological measures.

Mrs. Ek Chantho decided to practice crop rotation for a whole year whilst at the same time reducing the use of chemical fertilizers and pesticides because this can help her to reduce expenses. A further advantage for her is being a member of the safe vegetable growers group, as her contract with REMIC guarantees her sales of her vegetables to the company. Additionally she is able to sell any surplus safe vegetables to other traders once she has fulfilled her contractual obligations with REMIC. The decision to practice crop rotation also helped to maintain and increase soil fertility as a little organic and semi-organic fertilizer is added instead of chemical fertilizers. Furthermore the amount of chemical pesticides has been reduced due to the practice of crop rotation.

In this case, long beans, luffa, winter melons, pumpkins and cucumbers were rotated on the plot. This practice helps to keep the soil fertile and the nutrients balanced as land degradation can result from the cultivation of the same crop, as it will repeatedly absorb the same nutrients. Furthermore, crop rotation also contributes to a reduction in plant diseases and prevents an increase in damage from pests as it prevents a particular crop from building up pathogens in the soil. Each farmer will grow two or three different crops at the same time and then will chose to grow other crops in the following season. However, as the choice of a farmer's particular crop is coordinated by REMIC it ensures that each farmer in turn will assist in providing diversified crops to fulfil market demand.

The farmer stated that before practicing crop rotation, she mostly grew one or two crops which could be sold at a high price throughout the year. Therefore, in order to maintain her yields and prevent the crops from being damaged by insects she had to use a lot of chemical fertilizers and pesticides. However these only remained effective for a relatively short period and also increased her overheads. After having attended a course organized by Educational Concerns for Haiti Organization (ECHO), Rural Entrepreneurship & Market Inclusion in Cambodia (REMIC), and the Provincial Department of Agriculture she switched to crop rotation instead of cultivating one crop and to the use of organic and semi-organic fertilizers instead of chemicals. Furthermore her use of chemical pesticides also decreased as she followed standardized practices. This practice improves the soil

LOCATION



Location: Samekki Mean Chey district, Svay commune, Kyang Tboung village, Kampong Chhnang province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 104.71007, 11.81843

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 2016

Type of introduction

☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☑ through projects/ external interventions

quality, mitigates pests and diseases, reduces costs, improves income and also protects the health of producers and users.

As the farmers become highly efficient and the practice of crop rotation becomes sustainable they are able to improve their supply for the market. In fact, this has been successfully coordinated through REMIC's planning and contracting which ensures that there is always an adequate supply of diversified vegetables. Moreover, ECHO collaborated to check the use of chemical fertilizers and control pesticides which managed to raise consumer confidence by ensuring there are safe vegetables for the market, which in turn allowed farmers to set a high price for their produce.

Luffa crop (Mr. Sok Pheak)

Long bean in rotation after cucumber (Mr. Sok Pheak)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- ☐ improve production
- ☑ reduce, prevent, restore land degradation
- ☐ conserve ecosystem
- ☐ protect a watershed/ downstream areas – in combination with other Technologies
- ☐ preserve/ improve biodiversity
- ☐ reduce risk of disasters
- ☐ adapt to climate change/ extremes and its impacts
- ☐ mitigate climate change and its impacts
- ☑ create beneficial economic impact
- ☐ create beneficial social impact

Land use

Cropland - Annual cropping
Main crops (cash and food crops): long bean, luffa, cucumber, winter melon

Water supply

- ☐ rainfed
- ☑ mixed rainfed-irrigated
- ☐ full irrigation

Number of growing seasons per year: 2

Land use before implementation of the Technology: It is plantation land, but there was not much of crops and no rotation either.

Livestock density: n.a.

Purpose related to land degradation

- ☑ prevent land degradation
- ☑ reduce land degradation
- ☐ restore/ rehabilitate severely degraded land
- ☐ adapt to land degradation
- ☐ not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion

physical soil deterioration - Pc: compaction, Pu: loss of bio-productive function due to other activities

biological degradation - Bq: quantity/ biomass decline, Bp: increase of pests/ diseases, loss of predators

SLM group

- rotational systems (crop rotation, fallows, shifting cultivation)
- integrated soil fertility management
- integrated pest and disease management (incl. organic agriculture)

SLM measures

agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility

TECHNICAL DRAWING

Technical specifications

The total land area of the plot where the farmer practices this technique is 50 meters x 40 meters. This is divided into the section for long beans which measures 50 meters x 17 meters, and within this area the beans are planted in eight parallel rows with a distance of one meter between each of the rows. Each of these rows contains two lines that are a distance of 0.6 meters apart. In each of the lines the long beans have been planted with a one meter gap between each of the clumps. It is not necessary for the farmer to create a ridge in each of the rows and so in order plant the beans she just has to dig a hole measuring 15 cm x 15 cm with a depth of 15 cm and then ensure that the seedlings are planted at a depth of about 3 cm. The section of land for planting the luffa measures 50 meters x 23 meters and within this area is direct seedlings in 9 parallel rows with a gap of two meters between each of the rows. In each of the rows there is a distance of 1.2 meters between each of the clumps and these can be planted in holes with the same dimensions as the long beans.

Author: Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **40 m X 50 m = 200 m2**)
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 20000 Riel

Most important factors affecting the costs

The costs of the two-wheel tractor is high.

Establishment activities

1. Plow and dry (Timing/ frequency: April)
2. Digging hole (Timing/ frequency: April)
3. Apply organic fertilizer and cow manure (Timing/ frequency: April)
4. Seed cultivation (Timing/ frequency: April)
5. Buy pumping mechine (Timing/ frequency: April)

Establishment inputs and costs (per 40 m X 50 m = 200 m2)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Plow and dry	person-day	1.0	20000.0	20000.0	100.0
Apply organic fertilizer and cow manure	person-day	1.0	20000.0	20000.0	100.0
Digging and cultivation	person-day	5.0	20000.0	100000.0	100.0
Equipment					
Pumping machine	piece	1.0	1200000.0	1200000.0	100.0
Two-wheel tractor	piece	1.0	6000000.0	6000000.0	100.0
Plant material					
Long bean seeds	package	4.0	8000.0	32000.0	100.0
Luffa seeds	package	5.0	7000.0	35000.0	100.0
Fertilizers and biocides					
Organic fertilizer	sack	1.0	130000.0	130000.0	100.0
Semi-organic fertilizer	sack	1.0	130000.0	130000.0	100.0
Construction material					
Hoe	piece	2.0	9000.0	18000.0	100.0
Soil basket	piece	2.0	6000.0	12000.0	100.0
Trellising (using wood stick)	piece	1000.0	250.0	250000.0	100.0
Total costs for establishment of the Technology				**7947000.0**	

Maintenance activities

1. Watering (Timing/ frequency: In dry season every day and every week in rainy season)
2. Weeding (Timing/ frequency: Every week)
3. Trellising for long bean (Timing/ frequency: when 14-15 days old)
4. Applied pesticide (Timing/ frequency: Since 20 days on is applied every 7-10 days)
5. Pruning (Timing/ frequency: When 20-25 days old)

Maintenance inputs and costs (per 40 m X 50 m = 200 m2)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Watering and weeding	person-day	14.0	20000.0	280000.0	100.0
Trellising	person-day	3.0	20000.0	60000.0	100.0
Apply pesticide	person-day	6.0	20000.0	120000.0	100.0
Pruning	person-day	1.5	20000.0	30000.0	100.0
Total costs for maintenance of the Technology				**490000.0**	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate

Average annual rainfall in mm: 1209.0
The annual rainfall in 2015 was 1209 mm. In 2014 it was 1420.74 mm and in 2013 is was 1367.5 mm.
Name of the meteorological station: Department of Meteorology, Ministry of Water Resources and Meteorology (2015)

Slope
- ☑ flat (0-2%)
- ☐ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☑ plateau/plains
- ☐ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☑ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☐ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☑ very deep (> 120 cm)

Soil texture (topsoil)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Topsoil organic matter content
- ☐ high (>3%)
- ☑ medium (1-3%)
- ☐ low (<1%)

Groundwater table
- ☑ on surface
- ☐ < 5 m
- ☐ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☑ good
- ☐ medium
- ☐ poor/ none

Water quality (untreated)
- ☐ good drinking water
- ☐ poor drinking water (treatment required)
- ☑ for agricultural use only (irrigation)
- ☐ unusable

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☑ Yes
- ☐ No

Species diversity
- ☐ high
- ☐ medium
- ☑ low

Habitat diversity
- ☐ high
- ☐ medium
- ☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☐ mixed (subsistence/ commercial
- ☑ commercial/ market

Off-farm income
- ☐ less than 10% of all income
- ☐ 10-50% of all income
- ☑ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☐ poor
- ☑ average
- ☐ rich
- ☐ very rich

Level of mechanization
- ☐ manual work
- ☐ animal traction
- ☑ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative
- ☐ employee (company, government)

Gender
- ☑ women
- ☐ men

Age
- ☐ children
- ☐ youth
- ☑ middle-aged
- ☐ elderly

Area used per household
- ☑ < 0.5 ha
- ☐ 0.5-1 ha
- ☐ 1-2 ha
- ☐ 2-5 ha
- ☐ 5-15 ha
- ☐ 15-50 ha
- ☐ 50-100 ha

Scale
- ☑ small-scale
- ☐ medium-scale
- ☐ large-scale

Land ownership
- ☐ state
- ☐ company
- ☐ communal/ village
- ☐ group
- ☐ individual, not titled
- ☑ individual, titled

Land use rights
- ☐ open access (unorganized)
- ☐ communal (organized)
- ☐ leased
- ☑ individual

Water use rights
- ☑ open access (unorganized)

☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

☐ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor	☐ ☐ ✓	good
education	poor	☐ ☐ ✓	good
technical assistance	poor	☐ ☐ ✓	good
employment (e.g. off-farm)	poor	☐ ✓ ☐	good
markets	poor	☐ ☐ ✓	good
energy	poor	☐ ☐ ✓	good
roads and transport	poor	☐ ✓ ☐	good
drinking water and sanitation	poor	☐ ✓ ☐	good
financial services	poor	☐ ☐ ✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	Crop production increased due to crop rotation with using organic fertilizer and semi-organic fertilizer.
crop quality	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Crop quality is better because of using organic fertilizer instead of chemical fertilizer.
risk of production failure	increased	☐ ☐ ☐ ☐ ✓ ☐ ☐	decreased	To cultivate more than one crop helps to reduce risk of production failure.
land management	hindered	☐ ☐ ☐ ☐ ☐ ☐ ✓	simplified	Changing crop varieties and location.
expenses on agricultural inputs	increased	☐ ☐ ☐ ☐ ✓ ☐ ☐	decreased	Using chemical fertilizer is more expensive than organic fertilizer.
farm income	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Farm income increased because of reduced use of chemical fertilizer and cultivation of more than one crop.

Socio-cultural impacts

food security/ self-sufficiency	reduced	☐ ☐ ☐ ☐ ☐ ☐ ✓	improved	Getting high production and good market because she can become part of the safe vegetable growers group.
health situation	worsened	☐ ☐ ☐ ☐ ☐ ✓ ☐	improved	Health situation is improved due to changing from chemical fertilizer to organic fertilizer and semi-organic fertilizer.
SLM/ land degradation knowledge	reduced	☐ ☐ ☐ ☐ ☐ ✓ ☐	improved	They were trained by Rural Entrepreneurship & Market Inclusion in Cambodia (REMIC), Educational Concerns for Haiti Organization (ECHO) and Provincial Department of Agriculture.

Ecological impacts

water quality	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Due to reduced chemical fertilizers and pesticide application.
soil cover	reduced	☐ ☐ ☐ ☐ ☐ ✓ ☐	improved	Cultivation of crops all years round, which does not cause erosion as well as maintain soil moisture.
soil crusting/ sealing	increased	☐ ☐ ☐ ☐ ☐ ✓ ☐	reduced	When cultivation is all year round it helps to reduce evaporation that helps to reduce soil crusting.
soil compaction	increased	☐ ☐ ☐ ☐ ☐ ✓ ☐	reduced	Organic and semi-organic fertilizers using prevent soil from compaction which is good for the crops' root.
nutrient cycling/ recharge	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Nutrient cycling is improved due to changing the varieties of crops.
invasive alien species	increased	☐ ☐ ☐ ☐ ☐ ✓ ☐	reduced	Armyworm, mealybug, and lady bug is reduced by crop rotation practice.
beneficial species (predators, earthworms, pollinators)	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Beneficial species is increased after change from chemical fertilizer and pesticide to organic and semi-organic fertilizer.
pest/ disease control	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Pest or disease control is increased by reducing amount of mealybug and armyworm through

changing crop varieties.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐✓☐☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐✓☐☐	very positive

CLIMATE CHANGE

Gradual climate change

annual rainfall increase	not well at all	☐☐☐☐☐	very well	Answer: not known

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Number of households and/ or area covered

19 households

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- A good market has been created for the crops because by joining the Svaymeanchey Satrey Samaki Agricultural Cooperative with the practice of crop rotation throughout the whole year that the farmers are able to provide a regular supply.
- The reduction in the use of chemical fertilizers through the use of organic fertilizers and semi-organic fertilizers as well as the standardized use of chemical pesticides curtails the extension of negative impacts.
- The soil's nutrient content is balanced by not repeatedly cultivating one single crop on the same plot of land.
- Fertilizers and pesticides are purchased from an officially authorized company.

Strengths: compiler's or other key resource person's view

- A stable market has been created due to the Rural Entrepreneurship & Market Inclusion in Cambodia's (REMIC) involvement as the buyer.
- The farmers used to use a lot of chemical fertilizers on the land but now have switched to using organic and semi-organic fertilizers which they obtain from a licensed company. Moreover, chemical pesticides are used at the recommended level so that adverse impacts are avoided.
- The vegetables are safe as they are being monitored by ECHO.
- Crop rotation has improved the farmers' economic returns as it has enabled them to cultivate throughout the year-round and plant a crop based on market demand.
- The farmer has a clear understanding of sustainable land management through the practice of crop rotation with the limited use of chemical fertilizers and don't use chemical pesticides with high toxin that adversely affect the soil, the environment, humans and animals which the ministry of Agriculture Forestry and Fishery has banned.
- Besides using organic fertilizers and chemicals which have been purchased from an authorized company, the farmers

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Not yet adapted to climate change such as an increase in temperatures. → Unsure
- Limited knowledge of preventing the spread of insects and the use of natural fertilizers and botanical pesticides. → Can gain experience through more crop cultivation

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- Lack of effective technology to mitigate the effects of climate change such as floods, droughts or an increase in temperatures. → Need to check with planting schedule for the best time and need additional guidelines from relevant organizations as ECHO organization, who are responsible for monitoring and quality control as well as REMIC who is the buyer.
- Farmer still use chemical pesticides when insects damage their crops. → Train farmers to practice multiple cropping like grow protective crops such as herbs and lemongrass. Additionally farmers should be encouraged and trained to use botanical pesticides instead or apply integrated pest management (IPM).
- Farmers buy organic and semi-organic fertilizers from distributors which greatly adds to production costs. → Encourage farmers to produce liquid compost or dry compost by themselves so as to reduce the amount of fertilizers that are bought from distributors.
- The vegetables are safe but cannot be classed as organic. → Encourage farmers to grow organic vegetables.
- Farmers choose the type of vegetables for crop rotation based on market demands which are not suitable for this type of technology. For example the vegetables that are grown all belong to the same family (cucumber, wax melon, luffa and pumpkin). → Encourage crop rotation with different families of vegetables, which will not lead to a reduction in soil fertility.

now also use cow manure for their crops.

It would be better to firstly have a good understanding of the biological characteristics of each plant species.

REFERENCES

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Date of documentation: Sept. 1, 2017

Last update: Sept. 11, 2018

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_3165/

Linked SLM data
Approaches: A Safe Vegetable Growers Group in the Svaymeanchey Satrey Samaki Agricultural Cooperative
https://qcat.wocat.net/en/wocat/approaches/view/approaches_3216/

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

Key references

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C. Home garden and integrated farming system

Growing crops around house (Tim Sophea)

Home Garden (Pomelo, Lemon, Supplementary Crops) (Cambodia)

Mixed Cropping

DESCRIPTION

This technology involves the cultivation of crops around the house, including pomelos, lemons and other supplementary crops, with solely the application of cattle and chicken manure as fertilizer, whilst abstaining from the use of chemicals. The purpose of this technology is to obtain various products, generate a household income especially from the lemon trees as it is a long-term crop which provides a continuous supply of daily produce and is also relatively easy to grow, as well as to establish a comfortable environment for people to live in.

A home garden is the practice of planting different crops around the house such as a variety of vegetables, herbs, fruit trees, and other annual crops for the family's daily consumption as well as for commercial purposes. Home gardens have been set up in Cambodia and in many countries all over the world, albeit they might be named differently (Helen Keller International/Cambodia., 2003). This technique provides both economic and environmental benefits: generating household incomes and regulating the micro-climate by creating a desirable and ambient temperature around the house which makes the lives of family members more comfortable. More importantly, the technology provides opportunities for marginal groups like women, children, aging people and the disabled, to carry out agricultural work that contributes to an increase in household income (Landon-Lane C., 2012; Helen Keller International, 2010).

Home garden technique is being applied at Samraong village, Sambour commune, Sambour district, Kratie province, where the farmer is growing pomelo (30 trees) and lemon (10 trees) as the main crops for sale and other supplementary crops (banana, pineapple, pomegranate, lemongrass, coconut, mango and jackfruit mainly for household consumption. The technology is being implemented in an area of 1500 square meters (30x50 meters), with the Mekong River being located behind the house.

In order to plant the pomelo and lemon trees, the farmer digs 0.6 x 0.6 meter square pits that are 0.5 meters in depth. There is a distance of three meters from one pit to another to allow ample space for the trees to fully spread their branches. Animal manure is also added into the bottom of the pits. In addition, the farmer builds a small circular dike around the trunk of each pomelo and lemon tree in order to avoid water run-off while watering, and furthermore this can retain some water during rainfall. This technology only applies cattle and chicken manure, and avoids the use of chemical fertilizers.

Through the implementation of the home garden technology involving the cultivation of lemon and pomelo trees as the main produce as well as other supplementary crops, the farmer can gain many benefits. These include improving the farmer's daily income, creating greenery around the house and providing a favorable living environment that can adapt to the rising temperature caused by climate change. Also the technology is preventing or addressing soil erosion, and providing an appropriate environment for poultry raising. This technology is not expensive as the farmers are able to start implementing it on a step by step basis depending on the availability of labor and resources or they are also able to do it during their spare time.

Farmers can harvest lemons on a daily basis (around 10 to 15 kg per day) and also other supplementary crops. The pomelo trees produce fruit once per year (around 30 fruits per tree on average). In addition, such crop diversification also creates a natural habitat for

LOCATION

Location: Village land, Samrorng Village, Sambo Commune, Sambo District, Kratie Province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 106.00902, 12.71599

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 2010

Type of introduction

☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☐ through projects/ external interventions

biodiversity underground, which is an important factor in enhancing soil nutrients and other aggregates. It also avoids the use of chemicals that could harm the health of the family.


Pomelo and lemon crop around house (Tim Sophea)


Supplementary crops (Tim Sophea)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☑ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use

Cropland - Perennial (non-woody) cropping
Main crops (cash and food crops): Pomelo and lemon which can be harvested from the 3rd year and continue for about 15 years.

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 1

Land use before implementation of the Technology: Before the farmer was growing mango trees.

Livestock density: 20 chickens, cage size 3 x 5 = 15 square meters

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

biological degradation - Bl: loss of soil life

water degradation - Ha: aridification

SLM group

- integrated pest and disease management (incl. organic agriculture)
- home gardens

SLM measures

agronomic measures - A2: Organic matter/ soil fertility

structural measures - S4: Level ditches, pits

TECHNICAL DRAWING

Technical specifications

The total land area of the technology is 1500 square meters (30 m x 50 m), with the Mekong River behind the house. Within the home garden around the house, there are 30 trees of pomelo and 10 trees of lemon, together with another supplementary crops such as banana, coconut, lemongrass, coconut and pineapple. The space between lemon and pomelo trees is three meters and a small circular dike around the trunk of each pomelo and lemon tree is made to prevent water run-off. The other supplementary crops are scattered amongst the pomelo and lemon trees especially at the backyard and along the fence. The farmer used a pumping machine to pump the water from the river which was then connected with a pipe for irrigation.

Author: Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: 1500 square meters)
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 20000 /day

Most important factors affecting the costs

They use own labour and only natural fertilizer, so that they get more income and reduce costs.

Establishment activities

1. Buy pomelo it at Koh Trong (Timing/ frequency: Dry season)
2. Buy Lemon along road (Timing/ frequency: Dry season)
3. Buy equipment, pump machine, pipes (Timing/ frequency: Dry season)
4. Buy tools: hoe, shovel, basket (Timing/ frequency: Dry season)
5. Ridge of the row for plantation (Timing/ frequency: Dry season)
6. Plant the crops (Timing/ frequency: Rainy season)
7. Constructing small dikes around the tree trunks (Timing/ frequency: Dry season)

Establishment inputs and costs (per 1500 square meters)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Digging hole (own self)	day	10.0	20000.0	200000.0	100.0
Equipment					
Pumping machine and pipe	set	1.0	2000000.0	2000000.0	100.0
Hoe	piece	4.0	20000.0	80000.0	100.0
Shovel	piece	1.0	15000.0	15000.0	100.0
Basket	piece	5.0	10000.0	50000.0	100.0
Plant material					
Buy soil to fill	Small trucks	100.0	25000.0	2500000.0	100.0
Pomelo seedlings	Tree	30.0	40000.0	1200000.0	100.0
Lemon seedlings	Tree	10.0	15000.0	150000.0	100.0
Fertilizers and biocides					
Cattle Manure	Sack	20.0	3000.0	60000.0	100.0
Total costs for establishment of the Technology				**6255000.0**	

Maintenance activities

1. Puting fertilizer 3 times per year (Timing/ frequency: Early, middle and lately year)
2. Weeding (Timing/ frequency: Every week)
3. Watering (Timing/ frequency: Every 3 days)
4. Pick out some pomelo if it is too much (Timing/ frequency: For the first fruiting)
5. Spray mosquito killer to kill ants (Timing/ frequency: In rainy season during no rain)
6. Pomelo harvesting (Timing/ frequency: In May)
7. Lemon harvesting (Timing/ frequency: Everyday)

Maintenance inputs and costs (per 1500 square meters)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Put fertilizer (done by the farmer herself)	day	10.0	20000.0	200000.0	100.0
Weeding	times	32.0	14000.0	448000.0	100.0
Harvesting	hours	635.0	2500.0	1587500.0	100.0
Equipment					
Gasoline for pumping mechine	liters	608.0	3000.0	1824000.0	100.0
Fertilizers and biocides					
Manure	Sack	30.0	3000.0	90000.0	100.0
Total costs for maintenance of the Technology				4149500.0	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate
Average annual rainfall in mm: 1138.2
The average annual rainfall in 2015 is 1138.2 mm, in 2014 is 1696.5 mm, in 2013 is 1661.8 mm.
Name of the meteorological station: Department of Meteorology, Ministry of Water Resources and Meteorology (2015)
The weather is warm and humid with 2 different seasons: dry and rainy seasons.

Slope
- ☑ flat (0-2%)
- ☐ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☑ plateau/plains
- ☐ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☑ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☐ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☑ very deep (> 120 cm)

Soil texture (topsoil)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Topsoil organic matter content
- ☑ high (>3%)
- ☐ medium (1-3%)
- ☐ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☐ 5-50 m
- ☑ > 50 m

Availability of surface water
- ☐ excess
- ☑ good
- ☐ medium
- ☐ poor/ none

Water quality (untreated)
- ☑ good drinking water
- ☐ poor drinking water (treatment required)
- ☐ for agricultural use only (irrigation)
- ☐ unusable

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☑ Yes
- ☐ No

Species diversity
- ☐ high
- ☐ medium
- ☑ low

Habitat diversity
- ☐ high
- ☐ medium
- ☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☐ mixed (subsistence/ commercial
- ☑ commercial/ market

Off-farm income
- ☐ less than 10% of all income
- ☐ 10-50% of all income
- ☑ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☐ poor
- ☑ average
- ☐ rich
- ☐ very rich

Level of mechanization
- ☑ manual work
- ☐ animal traction
- ☑ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative
- ☐ employee (company, government)

Gender
- ☑ women
- ☐ men

Age
- ☐ children
- ☐ youth
- ☑ middle-aged
- ☐ elderly

Area used per household
- ☐ < 0.5 ha
- ☐ 0.5-1 ha
- ☐ 1-2 ha

Scale
- ☐ small-scale
- ☑ medium-scale
- ☐ large-scale

Land ownership
- ☐ state
- ☐ company
- ☐ communal/ village

Land use rights
- ☐ open access (unorganized)
- ☐ communal (organized)
- ☐ leased

☐ 2-5 ha
☑ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

☐ group
☑ individual, not titled
☐ individual, titled

☑ individual

Water use rights
☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor	☐ ☐ ✓	good
education	poor	☐ ☐ ✓	good
technical assistance	poor	☐ ☐ ✓	good
employment (e.g. off-farm)	poor	✓ ☐ ☐	good
markets	poor	☐ ☐ ✓	good
energy	poor	✓ ☐ ☐	good
roads and transport	poor	☐ ☐ ✓	good
drinking water and sanitation	poor	☐ ☐ ✓	good
financial services	poor	☐ ☐ ✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Increase around 20% if compare to previous productions of mango trees.
crop quality	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	Crop quality of both pomelo and lemon are increase slightly because there are enough water if compared to other place.
risk of production failure	increased	☐ ☐ ☐ ☐ ☐ ✓ ☐	decreased	Pomelo and lemon are higher demand that lead to increase household income by getting higher price.
product diversity	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	
land management	hindered	☐ ☐ ☐ ☐ ☐ ✓ ☐	simplified	The dike construction around tree trunks is keeping water for longer time.
demand for irrigation water	increased	☐ ☐ ☐ ✓ ☐ ☐ ☐	decreased	Water irrigation still demanded because beside of pomelo and lemon she planted as other crop mango trees.
expenses on agricultural inputs	increased	☐ ☐ ☐ ☐ ☐ ✓ ☐	decreased	Not using pesticides
farm income	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Additional profit of around 20%
diversity of income sources	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	Farmer received additional revenue after this practice
workload	increased	☐ ☐ ☐ ☐ ✓ ☐ ☐	decreased	The workload has decreased because previously she irrigated by hand, but now she is using a pump machine.

Socio-cultural impacts

food security/ self-sufficiency	reduced	☐ ☐ ☐ ☐ ☐ ✓ ☐	improved	She is obtainin higher yields
health situation	worsened	☐ ☐ ☐ ☐ ☐ ☐ ✓	improved	She does not use chemicals or other toxic elements at all.
SLM/ land degradation knowledge	reduced	☐ ☐ ☐ ☐ ☐ ✓ ☐	improved	The land user got knowledge about efficient water protection by dike construction around tree trunks and also about the positive effect of using of animal manure.

Ecological impacts

soil moisture	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	Because of dikes around the trunks that preserve water for longer time.
soil crusting/ sealing	increased	☐ ☐ ☐ ☐ ✓ ☐ ☐	reduced	Has been reduced by using natural fertilizers (chicken and cattle manure).
soil compaction	increased	☐ ☐ ☐ ☐ ✓ ☐ ☐	reduced	Can be reduced by using natural fertilizers (chicken and cattle manure).
soil organic matter/ below ground C	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	Increasing nutrition because plant leaves fall to the ground.
beneficial species (predators, earthworms, pollinators)	decreased	☐ ☐ ☐ ☐ ☐ ✓ ☐	increased	There is an increase as instead of chemical fertilizers

pest/ disease control	decreased				✓				increased

animals manure is used.

Pest and disease are normal because this technique doesn't focus on that. And further there are no chemical or biotic fertilizers in use.

Off-site impacts

water availability (groundwater, springs)	decreased				✓				increased
reliable and stable stream flows in dry season (incl. low flows)	reduced				✓				increased
groundwater/ river pollution	increased				✓				reduced

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative			✓					very positive
Long-term returns	very negative						✓		very positive

Benefits compared with maintenance costs

Short-term returns	very negative			✓					very positive
Long-term returns	very negative						✓		very positive

After 2-3 years they can harvest the fruits and it should continue for the next 15 years.

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes						
Climate-related extremes (disasters)							
local rainstorm	not well at all			✓			very well
local thunderstorm	not well at all			✓			very well
drought	not well at all			✓			very well
general (river) flood	not well at all			✓			very well
flash flood	not well at all			✓			very well
epidemic diseases	not well at all			✓			very well
insect/ worm infestation	not well at all			✓			very well
Other climate-related consequences							
extended growing period	not well at all			✓			very well
reduced growing period	not well at all			✓			very well
sea level rise	not well at all			✓			very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☑ single cases/ experimental
☐ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☐ 90-100%

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Easier to sell due to the high demand of lemons and pomelo which are not planted frequently.

Strengths: compiler's or other key resource person's view

- The kind of crops that can stand for a long time, provide high yields, be harvested for many years and the lemon crop delivers produce on a daily basis.
- There are lack of people growing pomelos and lemon trees in this area, so it is quite good for market demand.
- Applying animal manure can attain high yields and produce high quality crops.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Labor is needed to take care of the plants and to do the watering on a regular basis. → When busy, just keep it going on or take sometimes to do it specially in the early morning and evening after doing the other primary work.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

REFERENCES

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Date of documentation: April 24, 2017

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_2099/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

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Integrated Farming System (Mr. Tim Sophea)

Improved orchard with an integrated farming system (Cambodia)

Oun Chamkar Kroch

DESCRIPTION

The integrated farming system (IFS) includes basically the mixture of different farming components like crops, fruit tree cultivation, fish and livestock husbandry on the same farm plot. IFS help significantly to improve soil quality and crop production by using a minimum of external agricultural inputs.

Growing fruit trees is commonly practiced by Cambodian farmers, and there are different types of crops throughout the country. An integrated farming system is first of all an agricultural practice on a particular plot of land where crops, as well as livestock (pigs, and chickens), and fish are raised. The main purpose is to support and meet the farmers' need in getting more benefits and at the same time to promote ecological balance in the region. The integration of all, crop production, fish and livestock, is a simple mixture that has been applied by most farmers. The case study here picks out one particular farmer who applied this technology on his orchard, in an area of less fertile soil. This soil bear normally lower yields e.g. also in fruit tree cultivation. The farmer grew four types of fruit trees within his orchard, which included 150 pomelo trees, 25 mango trees, 11 tamarind trees and 10 lemon trees. Furthermore he raised fish and livestock on his plot, both with the aim of improving the soil condition to get better yield and crop quality. The mixture of different farming components and the resources recycling within the orchard reduced the use of external agricultural inputs and led him to nearly closed material cycle on his farm. By this, he supports to a more balanced ecosystem in the farm surroundings. At the same time he became more resilient to climate change impacts. However it took the farmer several years to rehabilitate the soil conditions by applying this kind of integrated farming system.

On the 8,400 square meter plot, the farmer has established four ponds for irrigation and fish farming. The space between the pomelo and the lemon trees were 5 m. The mango and tamarind trees were grown along the ponds and the fence with a space of five meter shaped in square. The main product was pomelo; besides this, the farmer has also raised 11 pigs and 100 chickens placed in separate cages to avoid outbreaks of disease. In order to promote the growth of his fruit trees, he applied manure from his pigs, cow dung and chickens. The ground around the trees was covered by rice straw to improve the soil moisture. In addition he had installed drip irrigation pipes to minimize the workload and to save water. For this kind of integrated farming system it is necessary to divide up the plots for the purpose of growing crops, livestock and fish farming; and these areas should interact within the farm.

The farmer gains a large number of benefits from the integrated farming in terms of household consumption and income. It also helps to regulate the natural environment by providing windstorm protection. Another purpose is not to use chemical fertilizer by using manure from livestock. And finally, Pomelo represents an important income source for the farmers and it has a strong market demand. It can be harvested twice a year; From the fourth year of cultivation the yield of one pomelo tree is about 70 to 200 fruits depending on its size ; per fruit the farmer gets about 6000 Riel (2017). The challenge of this technology is the considerable amount of time and money to for establish the technology. Anyway, the farmer expressed difficulties in raising capital to invest into the technology.

LOCATION

Location: Rural area, Kaeng Prasat village, Sambour Commune, Sambour District, Kratie Province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 105.97313, 12.76108

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 1998

Type of introduction

☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☑ during experiments/ research
☐ through projects/ external interventions


Ponds at both sides of the path and mango trees along the edge. (Mr. Tim Sophea)


Pond for the pipe irrigation system and for fish raising. (Mr. Tim Sophea)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- ☑ improve production
- ☑ reduce, prevent, restore land degradation
- ☐ conserve ecosystem
- ☐ protect a watershed/ downstream areas – in combination with other Technologies
- ☐ preserve/ improve biodiversity
- ☐ reduce risk of disasters
- ☐ adapt to climate change/ extremes and its impacts
- ☐ mitigate climate change and its impacts
- ☑ create beneficial economic impact
- ☐ create beneficial social impact

Land use

Mixed (crops/ grazing/ trees), incl. agroforestry - Agroforestry
Main products/ services: Pig and chicken, fish, pomelo, mango, sweet tamarind and lemons on same agricultural plot (Integrated Farming System)

Water supply

- ☐ rainfed
- ☑ mixed rainfed-irrigated
- ☐ full irrigation

Number of growing seasons per year: 1
Land use before implementation of the Technology: Before, forest land was kept for a long time on this plot.
Livestock density: 11 pigs, pig house is 42 square meter.

Purpose related to land degradation

- ☐ prevent land degradation
- ☑ reduce land degradation
- ☑ restore/ rehabilitate severely degraded land
- ☐ adapt to land degradation
- ☐ not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

physical soil deterioration - Pw: waterlogging

water degradation - Ha: aridification

SLM group

- integrated crop-livestock management
- integrated soil fertility management
- irrigation management (incl. water supply, drainage)

SLM measures

agronomic measures - A2: Organic matter/ soil fertility

structural measures - S5: Dams, pans, ponds, S7: Water harvesting/ supply/ irrigation equipment

management measures - M1: Change of land use type, M6: Waste management (recycling, re-use or reduce)

TECHNICAL DRAWING

Technical specifications

The integrated farming system is implemented on 8400 square meter of the land, including fruit trees such as 150 pomelo trees, 25 mango trees, 11 mango trees, and 10 lemon trees. Beside this, the farmer has four ponds for fish raising and irrigation, and 11 pigs which are putted separately in the cage of 42 square meter. The farmer grows the pomelo and lemon on row lines, the space between them is 5 m. Each pomelo and each lemon tree trunk is surrounded by the circular earth bund of 30 cm in height and at a diameter of 1m. They cover 240 square meters of the whole land area. The distance between the mango trees is 5 m and they surround the fishing ponds.

Author: Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **0.84 ha**)
- Currency used for cost calculation: **KHR (Riel)**
- Exchange rate (to USD): 1 USD = 4000.0 KHR (Riel)
- Average wage cost of hired labour per day: 20000 KHR

Most important factors affecting the costs

The farmer spent a lot of money on building pig house which cost 16,000,000 Riel equal to 4000 USD, tube system cost 8,000,000 Riel equal to 2000 USD, pumping machine cost 4,800,000 Riel equal to 1200 USD. In addition, he also spent on digging pond which cost 3,4000,000 Riel equal to 850USD. These components of the technology affects the costs for the establishement very much.

Establishment activities

1. Forest clearing (Timing/ frequency: Dry season)
2. Dig pond (Timing/ frequency: Dry season)
3. Land preparation and tube system (Timing/ frequency: Dry season)
4. Create circular earth bund around each fruit tree trunks and the soil mixed with organic fertilizer (pigs, cow dung, and chicken manure) (Timing/ frequency: During September)
5. buying seedling (Timing/ frequency: During September)
6. Growing fruit seedlings (Timing/ frequency: During September)
7. Building the pig house and tube system to flow the manure (Timing/ frequency: Dry season)
8. Buying pig (Timing/ frequency: Dry season)
9. Buying pig fodder (Timing/ frequency: Dry season)

Establishment inputs and costs (per 0.84 ha)

Specify input	Unit	Quantity	Costs per Unit (KHR (Riel))	Total costs per input (KHR (Riel))	% of costs borne by land users
Labour					
Forest clearing and land preparation	person-day	7.0	20000.0	140000.0	100.0
Digging pond	person-day	170.0	20000.0	3400000.0	100.0
Tube system installation	person-day	10.0	20000.0	200000.0	100.0
Planting of fruit trees	person-day	7.0	20000.0	140000.0	100.0
Equipment					
Pumping machine	Set	3.0	1600000.0	4800000.0	100.0
Knife	Piece	1.0	20000.0	20000.0	100.0
Ax	Piece	1.0	25000.0	25000.0	100.0
Two handled basket	Pair	1.0	14000.0	14000.0	100.0
Hoe	Piece	1.0	20000.0	20000.0	100.0
Tube system	Package	1.0	8000000.0	8000000.0	100.0
Plant material					
Pomelo tree	Tree	30.0	60000.0	1800000.0	100.0
Mango tree	Tree	25.0	6000.0	150000.0	100.0
Lemon	Tree	10.0	15000.0	150000.0	100.0
Tamarind	Tree	11.0	80000.0	880000.0	100.0
Fertilizers and biocides					
Cow dung and pig manure	Bag	33.0	3000.0	99000.0	100.0
Construction material					
Pig house	Piece	1.0	16000000.0	16000000.0	100.0
Other					
3 mother pigs and 1 boar	Number	4.0	1200000.0	4800000.0	100.0
Total costs for establishment of the Technology				**40638000.0**	

Maintenance activities

1. Watering once per week, if hotter, 4 days per week (Timing/ frequency: 32 weeks)
2. Cow dug once per 6 month (Timing/ frequency: Once per 6 months)
3. Pesticide spraying (Timing/ frequency: Presence of insects)
4. Branches and leaves cutting (Timing/ frequency: Clearing per year)
5. Grass clearing (Timing/ frequency: one week)

Maintenance inputs and costs (per 0.84 ha)

Specify input	Unit	Quantity	Costs per Unit (KHR (Riel))	Total costs per input (KHR (Riel))	% of costs borne by land users
Labour					
Maintaining labour	Person-day	240.0	20000.0	4800000.0	100.0
Plant material					
Diesel	Liter	315.0	3000.0	945000.0	100.0
Fertilizers and biocides					
Organic fertilizer (pigs, cow dung, and chicken manure)	Bag	50.0	44000.0	2200000.0	100.0
Total costs for maintenance of the Technology				**7945000.0**	

NATURAL ENVIRONMENT

Average annual rainfall
☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☑ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone
☐ humid
☑ sub-humid
☐ semi-arid
☐ arid

Specifications on climate
Average annual rainfall in mm: 1138.2
In 2015, the annual rainfall was 1138.2 mm,
in 2014, the annual rainfall was 1696.5 mm,
In 2013, the annual rainfall was 1661.8 mm.
Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)

Slope
☑ flat (0-2%)
☐ gentle (3-5%)
☐ moderate (6-10%)
☐ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☑ 0-100 m a.s.l.
☐ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☑ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☐ very deep (> 120 cm)

Soil texture (topsoil)
☑ coarse/ light (sandy)
☐ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☐ medium (1-3%)
☑ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☑ good
☐ medium
☐ poor/ none

Water quality (untreated)
☐ good drinking water
☐ poor drinking water (treatment required)
☑ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☑ Yes
☐ No

Species diversity
☐ high
☑ medium
☐ low

Habitat diversity
☐ high
☐ medium
☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☐ mixed (subsistence/ commercial
☑ commercial/ market

Off-farm income
☐ less than 10% of all income
☐ 10-50% of all income
☑ > 50% of all income

Relative level of wealth
☐ very poor
☐ poor
☑ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☐ animal traction
☑ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☐ women
☑ men

Age
☐ children
☐ youth
☑ middle-aged
☐ elderly

Area used per household

☐ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☑ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale

☐ small-scale
☑ medium-scale
☐ large-scale

Land ownership

☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights

☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights

☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor	☐	☐	☑	good
education	poor	☐	☐	☑	good
technical assistance	poor	☐	☑	☐	good
employment (e.g. off-farm)	poor	☐	☑	☐	good
markets	poor	☐	☐	☑	good
energy	poor	☐	☑	☐	good
roads and transport	poor	☐	☐	☑	good
drinking water and sanitation	poor	☐	☑	☐	good
financial services	poor	☐	☑	☐	good

IMPACTS

Socio-economic impacts

Crop production — decreased ☐ ☐ ☐ ☐ ☐ ☑ ☐ increased

Although the farmer cultivated always on less fertile soil, by the Integrated Farming System he was able to optimize substantially the production (by large variety of different cultures on a limited space and products such as fruit trees, pigs, fish, more efficiency at cycling of nutrients and farm materials, etc).

crop quality — decreased ☐ ☐ ☐ ☐ ☐ ☑ ☐ increased

The pest control and the soil fertility by applying organic fertilizer have been improved slightly due to the fact that the farm ecosystem is better balanced now. In addition, he has enough ponds which ensure the water supply to the crops all year round. This may be reasons that he gets far better crop quality, now.

risk of production failure — increased ☐ ☐ ☐ ☐ ☐ ☑ ☐ decreased

By the advantages of the mixed production system he was able to alleviate the farming risks caused by the exposure to climate change related uncertainties such as floods, change in rainfall pattern, drought, fluctuating market prices and diseases.

product diversity — decreased ☐ ☐ ☐ ☐ ☐ ☑ ☐ increased

Compared with the past, where he didn't implement IFS on his farm (mono-cropping), the product diversity now has been increased substantially and was reinforced by the good market demand during the last years.

land management — hindered ☐ ☐ ☐ ☐ ☐ ☑ ☐ simplified

Although the soil is difficult to grow fruit trees, he was able to improve the soil by using organic fertilizers (pigs, cow dung, and chicken manure). In consequence, the the land management was simplified

water availability for livestock — decreased ☐ ☐ ☐ ☐ ☐ ☑ ☐ increased

After the digging fo the ponds, water for the livestock, the pigs and the chicken is available all year round.

irrigation water availability — decreased ☐ ☐ ☐ ☐ ☐ ☑ ☐ increased

The farmer used the water from the new ponds for watering fruit trees.

expenses on agricultural inputs — increased ☐ ☑ ☐ ☐ ☐ ☐ ☐ decreased

Spending more money on establishment activities (mainly the pig house, irrigation system and the ponds etc).

farm income — decreased ☐ ☐ ☐ ☐ ☐ ☑ ☐ increased

Due to good market prices for his pomelo variety, the supplement fish production and the nearly close nutrient cycle on his farm that reduced the expenditure on chemical fertilizer the income increased constantly.

diversity of income sources — decreased ☐ ☐ ☐ ☐ ☐ ☐ ☑ increased

Compared to the former mono-cropping system, the large variety of products produced on his farm since 1998 has diversified the income sources substantially through this technology.

workload	increased						✓		decreased	Using pumping machine for irrigating the fruit trees.

Socio-cultural impacts

food security/ self-sufficiency	reduced						✓		improved	The diversification of the production in very good quality providing good nutrition to human also enhanced the food security, as there are always farm products which can be sold on the market.
health situation	worsened							✓	improved	No chemical fertilizer and less of pesticide is used now.
land use/ water rights	worsened							✓	improved	Due to the ponds on own farm area, the water right security has been improved significantly. However, he was already in possession of land titles.
recreational opportunities	reduced							✓	improved	As in paradise – that's what it feels walking through the multi-purpose and inspiring farm area. The farmer enjoys farming under these conditions."
community institutions	weakened							✓	strengthened	By his success of practicing the technology of IFS, he was able to share his knowledge with local people on farm. In addition, he propagated (macrotting) pomelo tree plants and shared them with village people free of charge (one pomelo tree plant per family who was interested to plant this kind of crop).
national institutions	weakened							✓	strengthened	Relevant stakeholders are interested in the integrated farming system.
SLM/ land degradation knowledge	reduced							✓	improved	He understands now that it was necessary to add fertile soil from other places to the degraded land in regard to improve the crop growing. In addition, he learned how to avoid chemical fertilizer which could make the soil compact and finally in the future less fertile. Further, he learned by experience how to apply organic fertilizers that enhanced the land rehabilitation.

Ecological impacts

harvesting/ collection of water (runoff, dew, snow, etc)	reduced						✓		improved	There are 4 ponds for rainfall water harvesting to irrigat crop or animals raising during drought.
excess water drainage	reduced							✓	improved	The larger amount of installed pipes improved substantially the excess water drainage.
evaporation	increased					✓			decreased	The shadow from the fruit trees and the rice straw as soil cover reduced the evaporation.
soil moisture	decreased						✓		increased	The soil moisture increased as he covers the soil by rice straw and fruit trees.
soil cover	reduced						✓		improved	The high amount of fruit trees cover soil very well. In addition, rice straw is covering the soil arround the fruit tree trunks.
soil crusting/ sealing	increased							✓	reduced	Due to the regular application of organic fertilizer and rice straw the soil crusting and sealing can be minimized.
soil organic matter/ below ground C	decreased						✓		increased	The application of organic fertilizer (pigs, cow dung, and chicken manure) increased the soil organic matter.
plant diversity	decreased							✓	increased	Due to the higher variety of fruit trees.
pest/ disease control	decreased							✓	increased	This integrated farming system avoids plant and fruit diseases and pests substantially due to favourable environmental conditions (better microclimate, better balancing of pests and beneficial organisms).
drought impacts	increased						✓		decreased	During drought situations, the farmer can use now water from ponds to irrigate the fruit trees.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative		✓						very positive
Long-term returns	very negative							✓	very positive

Benefits compared with maintenance costs

Short-term returns	very negative		✓						very positive
Long-term returns	very negative							✓	very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes							
Gradual climate change								
annual temperature increase	not well at all			✓			very well	
seasonal temperature increase	not well at all					✓	very well	Season: wet/ rainy season
seasonal temperature decrease	not well at all			✓			very well	Season: dry season
seasonal rainfall increase	not well at all				✓		very well	Season: wet/ rainy season
seasonal rainfall increase	not well at all	✓					very well	Season: dry season
Climate-related extremes (disasters)								
tropical storm	not well at all			✓			very well	
extra-tropical cyclone	not well at all				✓		very well	
heatwave	not well at all			✓			very well	
drought	not well at all			✓			very well	
general (river) flood	not well at all			✓			very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☑ single cases/ experimental
☐ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Has the Technology been modified recently to adapt to changing conditions?

☑ Yes
☐ No

To which changing conditions?

☑ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- High market price for the products.
- He spends almost all his free time to work in the farm to relax and enjoy farming.
- More income for the land user's family.

Strengths: compiler's or other key resource person's view

- The soil's quality is improved due to integrated farming and the use of organic fertilizer.
- The crops are long-lasting and can continue to be harvested annually.
- Labor and time are saved by using an irrigation system.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- The high expense on digging the ponds. → Taking time and money before practicing the technique.
- Pomelo could not be able to grow in the wet soil. → Change crop varieties.
- During the drought period, the technology practice has an increase in the number of insects, and they sometime could not be able to control like happening in 2015. → Use pesticide to kill the insects.
- The soil within the farm is difficult to convert from less fertile soil to fertile soil, and take many years to be ready for cropping. It is called Prateah Lang soil. → Change the type of soil for cropping by using a mixture of animal manure and mountain soil.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- Need to invest more capital. → This should be done step by step.
- Less fertile soil → Soil conversion by mixing animal manure and fertile soil and spreading this on the area's crop land.

REFERENCES

Compiler
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Date of documentation: May 17, 2017

Last update: Jan. 22, 2018

Resource persons
Chetana Keat (N/A) - land user
Sivin Sak (saksivin@gmail.com) - Chief of District Office of Agriculture, Forestry and Fisheries of Sambour
vann vun (vannvun278@gmail.com) - Acting Chief of District Office of Agriculture, Forestry and Fisheries of Prek Prasab
Saravuth Ly (saravuthly123@gmail.com) - Official of District Office of Agriculture, Forestry and Fisheries of Chetr Borei

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_2263/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

Key references

- Seng, V. (2010). Agricultural Best Practices for Sustainable Land Management in Cambodia. Phnom Penh: Cambodian Agricultural Research and Development Institute.: CARDI

D. Manuring and composting

Biodigester system (Mr. Kim Soben)

Using slurry from biodigester for soil improvement (Cambodia)

biodigester

DESCRIPTION

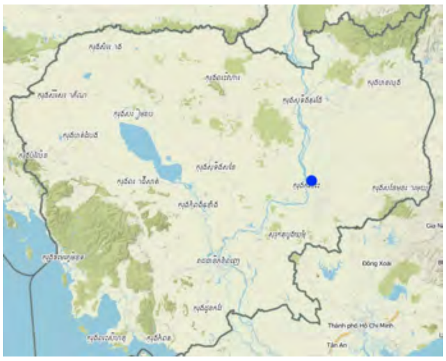
Biodigester slurry sourced from cow manure is used as an important natural fertilizer for the cultivation of crops. It is a form of organic fertilizer that is thoroughly decomposed, does not have an awful smell, or contain living weed seeds, fungi and other viruses. It can also be used immediately after the slurry flows out of the biodigester tank. Such fertilizer helps to improve the soil quality in the long-term due to the rich organic matter that it contains which slowly decomposes to plant nutrients.

There are many kinds of biodigesters and the one used in this technology is a 5000 liter plastic cylinder. It was installed by placing part of the tank into the ground and setting up an inlet-outlet pipe as well as a gas pipe system. The whole installation process takes around a day to complete. In order to produce gas initially the biodigester needs about 120 buckets (around 2000 kg) of fresh cow manure and 120 buckets (1200 liters) of water, which then needs to be kept for one week so that it can produce gas and slurry as fertilizer. After that the farmer has to add one bucket (around 20 kg) of fresh cow manure and one bucket (20 liters) of water every day in order to maintain the continuous production of gas and slurry. As a result, the farmer's family has gas from the biodigester which provides sufficient energy for cooking. In this way they are able to save time which is otherwise spent collecting fuel-wood and it reduces their firewood consumption by around 2190 kg per year. The fresh cow manure for the biodigester should be free from rubbish and not contain small gravel because this blocks the inlet /outlet of the biodigester tank.

In addition, to be able to use the gas for cooking and lighting, the farmer also has the opportunity of using the slurry from the biodigester as fertilizer for all kinds of crops, including bitter gourds, eggplants, mangos, yard long beans, rice, bamboo shoots and other supplementary crops. The slurry from the biodigester can be applied as fertilizer either in a liquid, a semi-dry or a dry form. The slurry can be applied to the crops directly or compost can be made by mixing it with other degradable materials such as woody herb, rice straw and other green leaves. This practice will increase the quantity of the fertilizer because the slurry from bioidigester helps to accelerate the decomposition process and it also produces a higher quality compost.

The slurry from biodigester improves soil aggregates and fertility for a longer period than chemical fertilizers. The slurry contains a lot of nutrients specially nitrogen, phosphorus and potassium that are necessary for plants, and it does not have an awful smell, or contain weed seeds and parasites. The nutrients are in a chemical form which can easily be absorbed by plants, and it contains vitamin B12 which stimulates the growth of earth worms. The use of slurry enables the growth of various microorganisms and besides earth worms, other useful animals such as frogs and soil-insects, thereby maintaining a natural balance of the environment. The fertilizer enhances the growth of crops, builds resistance to disease, and does not affect the soil and human health. For poorer quality soil, the slurry or compost improves both the physical and biological conditions of the soil. It improves the nutrient content including macronutrients and micronutrients, and also helps to keep soil aggregates and moisture.

LOCATION



Location: Rural , Kamboa village, Kouleap commune, Chitrborie district, Kratie province., Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 106.08695, 12.54908

Spread of the Technology: applied at specific points/ concentrated on a small area

Date of implementation: 2016

Type of introduction

☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☑ through projects/ external interventions


Farmer taking compost produced from the slurry to apply it on crops (Mr. Kim Soben)


Using the slurry compost on eggplant and mango (Mr. Kim Soben)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☑ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☑ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☑ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use

Cropland - Annual cropping, Perennial (non-woody) cropping, Tree and shrub cropping
Main crops (cash and food crops): Rice, sugar cane, banana, eggplant, bitter gourd, yard long bean, mango and other vegetable.

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 3

Land use before implementation of the Technology: This land was previously degraded forest land.

Livestock density: Raising of 19 cows to supply manure for the biodigester and also around 100 chicken

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

physical soil deterioration - Pu: loss of bio-productive function due to other activities

biological degradation - Bs: quality and species composition/ diversity decline, Bl: loss of soil life

SLM group

- integrated crop-livestock management
- energy efficiency technologies

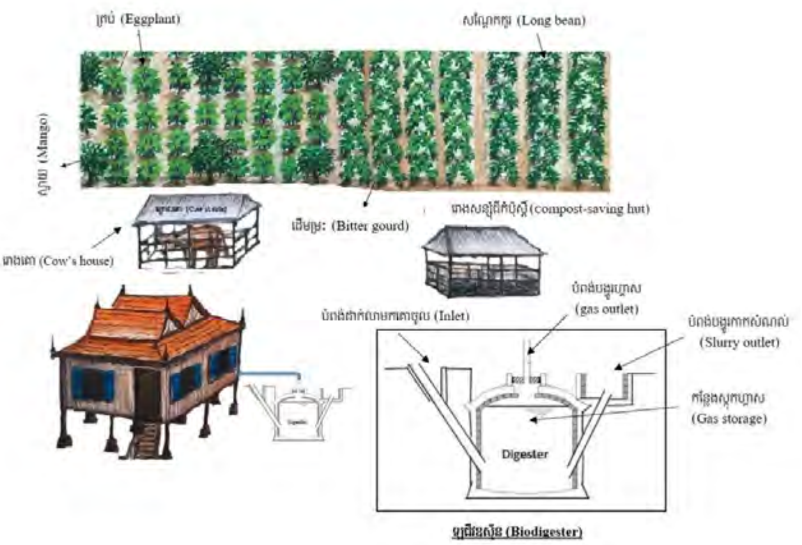
SLM measures

management measures - M6: Waste management (recycling, re-use or reduce)

TECHNICAL DRAWING

Technical specifications

Biodigester tank is made of a plastic tank of 5,000 liter volume. The biodigester structure has three pipes: inlet, gas pipe and outlet. The inlet is for pouring the mixed fresh cow manure into the biodigester tank, while outlet is where the slurry comes out. The pipe is for delivering gas from the biodirester to the end use places. The tank is buried at one-third of the height into the ground. On a daily basis, it needs around 20kg cow manure mixed with 20 litres of water, putting into the tank. There is a hut (3×3 meters sides with 1.6 meters high) for storing the slurry and making compost. The roof is made of zinc at 0,5 meters height above the wall. Bio-digester fertilizers are used on many types of crops in the fields. It can produce around 4 cubic meters of gas, offsetting the use of around 2,190 kg of firewood per year.



Author: Mr. Khoun Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology unit (unit: **Biodigester**)
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 25000 riel

Most important factors affecting the costs

The cost of the plastic tank and the enough cows to producing sufficient slurry for the manure production.

Establishment activities

1. Dig soil (Timing/ frequency: May)
2. Put biodigester (Timing/ frequency: May)
3. Prepare pipe system (Timing/ frequency: May)
4. Install (Timing/ frequency: May)
5. Add cow manure (Timing/ frequency: May)

Establishment inputs and costs (per Biodigester)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Equipment					
Biodigester	set	1.0	4000000.0	4000000.0	20.0
Total costs for establishment of the Technology				**4000000.0**	

Maintenance activities

1. Clean drainage pipes (Timing/ frequency: every day)
2. Putting cow manure (Timing/ frequency: every day)

Maintenance inputs and costs (per Biodigester)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Cleaning by themself	Hour	30.42	3124.0	95032.08	100.0
Fertilizers and biocides					
Cow manure	Kg	20.0	1200.0	24000.0	100.0
Water	Liter	20.0	200.0	4000.0	100.0
Total costs for maintenance of the Technology				**123032.08**	

NATURAL ENVIRONMENT

Average annual rainfall

- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone

- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate

Average annual rainfall in mm: 1138.2
The average annual rainfall in 2015 is 1138.2 mm, in 2014 is 1696.5 mm, in 2013 is 1661.8 mm.
Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)

Slope
☑ flat (0-2%)
☐ gentle (3-5%)
☐ moderate (6-10%)
☐ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☑ 0-100 m a.s.l.
☐ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☑ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☐ very deep (> 120 cm)

Soil texture (topsoil)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☐ medium (loamy, silty)
☑ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☐ medium (1-3%)
☑ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☑ good
☐ medium
☐ poor/ none

Water quality (untreated)
☑ good drinking water
☐ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☐ high
☐ medium
☑ low

Habitat diversity
☐ high
☐ medium
☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☐ mixed (subsistence/ commercial
☑ commercial/ market

Off-farm income
☐ less than 10% of all income
☑ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
☐ poor
☑ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☐ animal traction
☐ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☐ women
☑ men

Age
☐ children
☐ youth
☑ middle-aged
☐ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☑ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☐ small-scale
☑ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor	✓			good
education	poor	✓			good
technical assistance	poor		✓		good
employment (e.g. off-farm)	poor		✓		good
markets	poor			✓	good
energy	poor			✓	good
roads and transport	poor			✓	good
drinking water and sanitation	poor			✓	good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased							✓	increased
crop quality	decreased							✓	increased

Quantity before SLM: 150 kg per month
Quantity after SLM: 450 kg per month

Biodigester slurry is a rich-nutrient natural fertilizer and the produced crop is not chemically contaminated.

animal production	decreased	☐☐☐☐☐☐☑	increased	Quantity before SLM: 10 Cows Quantity after SLM: 19 cows As cow manure is needed for the biodigester to produce enough gas and compost, the herd size had to be increased.
risk of production failure	increased	☐☐☐☐☐☑☐	decreased	As the farmer was able to scale up the plant variety by using slurry from biodigester the risk of production shortfall for one crop can be compensated by the other crops.
product diversity	decreased	☐☐☐☐☐☑☐	increased	As the slurry from biodigester matches to all sorts of plants, the farmer was able to scale up the product diversity.
land management	hindered	☐☐☐☐☐☐☑	simplified	Quantity before SLM: Use chemical fertilizer Quantity after SLM: Use compost fertilizer Fertilizer now is produced on farm in a very short time and therefore farmer doesn't have to run after manure.
energy generation (e.g. hydro, bio)	decreased	☐☐☐☐☐☐☑	increased	Before the farmer family was forced to look for huge amounts of fire wood (over 1,290 kg per year) in the surrounding area. Now, as side effect of the compost production gas can be produced for cooking.
expenses on agricultural inputs	increased	☐☐☐☐☐☐☑	decreased	No chemical fertilizer has to be bought.
farm income	decreased	☐☐☐☐☐☐☑	increased	Quantity before SLM: 15 % Quantity after SLM: 45 % The farmer now has diversified productions from the various crops due to the improved soil quality, thus, the household income increased substatially.
workload	increased	☐☐☐☐☐☑☐	decreased	Stop going to the forest to collect fire wood.
Socio-cultural impacts				
food security/ self-sufficiency	reduced	☐☐☐☐☐☐☑	improved	The farmer now have enough and healthy food for the whole year and surplus for selling.
health situation	worsened	☐☐☐☐☐☑☐	improved	Compared to former time, the family is less sick which is closely associated healthier food production and the and the cleaner air during cooking.
SLM/ land degradation knowledge	reduced	☐☐☐☐☐☐☑	improved	The farmer participated in training on compost and vegetable growing including some field visits.
Ecological impacts				
evaporation	increased	☐☐☐☐☑☐☐	decreased	Due to the better availability of fertilizer, the farmer grows more crops on his land during the whole year. In cosequence of this, the evaporation is slightly reduced. Also, higher plants such as mango trees provide more shade to the land.
soil moisture	decreased	☐☐☐☐☑☐☐	increased	The increase in organic matter and the better soil cover by plants improved the soil moisture slightly.
soil cover	reduced	☐☐☐☐☐☑☐	improved	During all seasons the soil is now covered by plants.
soil organic matter/ below ground C	decreased	☐☐☐☐☐☑☐	increased	Soil rich in nutrients due to the frequent compost application
plant diversity	decreased	☐☐☐☐☐☑☐	increased	Due to beneficial soil conditions, plant diversity increased.
animal diversity	decreased	☐☐☐☐☐☑☐	increased	Increase in number of frog, worm, and earthworm
beneficial species (predators, earthworms, pollinators)	decreased	☐☐☐☐☐☑☐	increased	More frogs, worms, and earthworms
pest/ disease control	decreased	☐☐☐☐☑☐☐	increased	There are still some insects damaging plant leaves, but compared to before the number has decreased due to the healthier soil conditions.
Off-site impacts				
impact of greenhouse gases	increased	☐☐☐☐☐☑☐	reduced	No burn of firewood for cooking and preservation of forests for carbon sequestration

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative							✓	very positive
Long-term returns	very negative							✓	very positive

Benefits compared with maintenance costs

Short-term returns	very negative							✓	very positive
Long-term returns	very negative							✓	very positive

No money was needed to repair the biodigester system untill now.

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes							
Gradual climate change								
annual temperature increase	not well at all			✓			very well	
seasonal temperature increase	not well at all			✓			very well	Season: wet/ rainy season
annual rainfall increase	not well at all			✓			very well	
seasonal rainfall increase	not well at all			✓			very well	Season: wet/ rainy season
Climate-related extremes (disasters)								
drought	not well at all				✓		very well	
epidemic diseases	not well at all			✓			very well	
insect/ worm infestation	not well at all			✓			very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☑ 0-10%
☐ 10-50%
☐ 50-90%
☐ 90-100%

Number of households and/ or area covered
Six households have been supported to get the biodigester by the NBP.

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Manufacture fertilizer by himself
- Can be applied directly to the crop which not results in its putrefy, unlike fresh cow manure which can lead to the putrescence of crops and the growth of a lot of grass.
- Saving of 2190 kg of firewood per year.

Strengths: compiler's or other key resource person's view

- Helps to improve the soil quality.
- Reduces negative environmental effects.
- Reduces daily costs.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- A biodigester is expensive → National biodigester programme to support

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- A biodigester is expensive → Need a supporting fund from relevant institutions.
- Need of enough cow manure → Promote livestock raising, especially cows.

REFERENCES

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Date of documentation: May 2, 2017

Last update: Jan. 15, 2018

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_2137/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

Key references
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Links to relevant information which is available online
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Herbs plantation under long bean by using cow manure and liquid compost (Mr. Kim Soben)

Sandy soil improvement by using natural fertilizer and liquid compost (Cambodia)

Long bean plantation

DESCRIPTION

The practice of improving the conditions of a sandy soil by natural fertilizers and liquid compost application increases the crop production, as it leads to a substantial improvement of the soil quality. It improves the water retention capacity, improves the soil structure (less compaction), eases the nutrient absorption and finally, increases the soil fertility in general.

A sandy soil is a soil type with large particles that has difficulty in retaining both moisture and fertility, which makes it challenging for crop cultivation. Therefore, a practice is needed that helps farmer to improve the quality of such soils. Improving soil quality means to promote a process of constant improvement of soil fertility by maintaining soil moisture, reducing soil compaction, and support to better nutrient absorption, thereby finally promoting better plant growth. Sandy soils are relatively compact and can hamper the growth and penetration of plant roots, what hinders the absorption of nutrients. To reduce this effect, the incorporation of organic matter can be useful (Rhoades, 2016). The farmers have their own techniques to improve sandy soils; one example is the diversified crop cultivation by using natural fertilizer and liquid compost. This technology is applied by one of farmers in the Prey Puoch village, belonging to the Rolea B'ier District.

His objective was to improve sandy soils in order to achieve higher production. Apart of the application of liquid compost and natural fertilizers – and consequently the improvement of the soil nutrient status – the farmer also increased the range of crops to raise the production level. Therefore, the family was able to raise its surpluses to be sold at the markets significantly. This led to a meaningful improvement of the livelihood.

The farmer use only natural fertilizers, such as crops residue, and cow manure or manure from pigs, when cow manure is not available. Although pig manure does not contain the same high level of nutrients as cow manure, it helps to reduce soil compaction, allows crop's roots to absorb nutrients, and improves soil moisture. In addition, liquid compost can be applied to increase soil fertility, as this kind of compost is rich in microorganisms that play an important role in the decomposition of organic materials. By this, nutrients can be provided in the best possible way. The farmer has planted long beans and other trellising plants in rotation and as inter-crops for example strongly smelling spring onion and anise basil. Such crops grown beneath the long beans can help to reduce pest damage and diminish the use chemical pesticides. Plating anise basil and spring onions along each long bean row and the rotation practices also help maintaining the nutrition level in the soil.

To make liquid compost the farmer uses two main ingredients, such as animal (poultry) manure and plant leaves (Siam weed, Cassia tree, Lead tree, Sesbania, etc.). All of the materials are chopped and mixed, and then put into a big jar with 20 times the volume of water being added. The jar is then closed to reduce the unpleasant smell. The mixture is stirred twice daily to provide enough oxygen for the microorganisms. After three weeks the liquid mixture will be no longer smelly, and will be ready for use as liquid compost. This compost is applied three times during the crop cycle: at the start of planting, just before the flowering stage, and at the production stage. The ratio of application is 1 liter of the liquid compost for each square meter of land (Yang and Pean, 2015).

Before the farmer adopted this technology they could not even grow water morning

LOCATION

Location: Prey Puoch village, Chrey Bak commune, Rolea B'ier District, Kampong Chhnange province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 104.66207, 12.21599

Spread of the Technology: evenly spread over an area

Date of implementation: 2016

Type of introduction

☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☐ through projects/ external interventions

glory and they needed a lot of labor and much water for the irrigation. This practice not only helps to improve soil quality, it reduces also the costs by using less chemical fertilizers and pesticides, by reducing the labour input, and it helps to expand the area of arable land.


Spring onion cultivation under long bean plants with drip system (Mr. Kim Soben)


Basil cultivation under long bean plants (Mr. Kim Soben)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- ☑ improve production
- ☑ reduce, prevent, restore land degradation
- ☐ conserve ecosystem
- ☐ protect a watershed/ downstream areas – in combination with other Technologies
- ☐ preserve/ improve biodiversity
- ☐ reduce risk of disasters
- ☐ adapt to climate change/ extremes and its impacts
- ☐ mitigate climate change and its impacts
- ☑ create beneficial economic impact
- ☐ create beneficial social impact

Land use

Cropland - Annual cropping
Main crops (cash and food crops): There are three types of crops such as Long bean, Anise Basil and Spring onion.

Water supply

- ☐ rainfed
- ☑ mixed rainfed-irrigated
- ☐ full irrigation

Number of growing seasons per year: 3

Land use before implementation of the Technology: Rice field with low yield due to the sandy soil

Livestock density: n.a.

Purpose related to land degradation

- ☐ prevent land degradation
- ☐ reduce land degradation
- ☑ restore/ rehabilitate severely degraded land
- ☐ adapt to land degradation
- ☐ not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion

water degradation - Ha: aridification

SLM group

- rotational systems (crop rotation, fallows, shifting cultivation)
- integrated soil fertility management
- integrated pest and disease management (incl. organic agriculture)

SLM measures

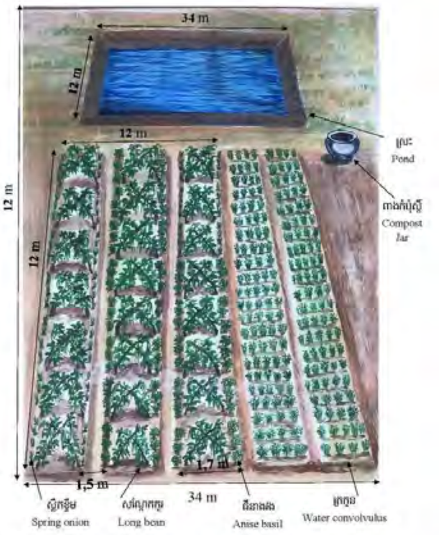
agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility

structural measures - S7: Water harvesting/ supply/ irrigation equipment

TECHNICAL DRAWING

Technical specifications

This technique is applied on the land with 24 x 52 meters land that contains a pond at the back of the field (22 x 34 meters width and length respectively and 5 meters depth). The remaining land is covered by long bean, 12 x 30 meters with rows of long bean is 1.7 meters wide, row gap is 1.5 meters, height is 30 centimeters, and 40 cm space between plant to plant is. On the size is cover by long bean 3 rows as 6 lines, each rows are 40 centimeters gap with anise basil plantation and spring onion between long bean. To make liquid compost the farmer uses two main ingredients, such as animal (poultry) manure and plant leaves (Siam weed, Cassia tree, Lead tree, Sesbania, etc.). All of the materials are chopped and mixed, and then put into a big jar with 20 times the volume of water being added. The jar is then closed to reduce the unpleasant smell. The mixture is stirred twice daily to provide enough oxygen for the microorganisms. After three weeks the liquid mixture will be no longer smelly, and will be ready for use as liquid compost. This compost is applied three times during the crop cycle: at the start of planting, just before the flowering stage, and at the production stage. The ratio of application is 1 liter of the liquid compost for each square meter of land.



Author: Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: 12 X 30 = 360 square meters)
- Currency used for cost calculation: **KHR**
- Exchange rate (to USD): 1 USD = 4000.0 KHR
- Average wage cost of hired labour per day: 25000 Riel

Most important factors affecting the costs

Irrigation preparation (drip irrigation)

Establishment activities

1. Ploughing (Timing/ frequency: May)
2. Lime spreading (Timing/ frequency: May)
3. Row preparation (Timing/ frequency: May)
4. Putting cow manure and fertiled soil (Timing/ frequency: May)
5. Installation of drip irrigation system (Timing/ frequency: May)
6. Do the trellising (Timing/ frequency: May)
7. Do the nursery (Timing/ frequency: May)

Establishment inputs and costs (per 12 X 30 = 360 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
Ploughing	times	3.0	20000.0	60000.0	100.0
Rows preparation and lime spreading	day	2.0	25000.0	50000.0	100.0
Preparing drip irrigation	day	1.0	25000.0	25000.0	100.0
Equipment					
Spade	piece	1.0	15000.0	15000.0	100.0
Hoe	piece	1.0	20000.0	20000.0	100.0
Shovel	piece	1.0	20000.0	20000.0	100.0
Plant material					
Long bean seeds	package	1.0	10000.0	10000.0	100.0
Spring onion seeds	kg	3.0	4000.0	12000.0	100.0
Tray seeding	piece	6.0	4000.0	24000.0	100.0
Fertilizers and biocides					
Cow manure	ox-driven vehicle	6.0	20000.0	120000.0	100.0
DAP fertilizer	kg	5.0	3000.0	15000.0	100.0
KCL fertilizer	kg	5.0	3000.0	15000.0	100.0
Urea fertilizer	kg	5.0	3500.0	17500.0	100.0
Construction material					
Drip system	set	1.0	110000.0	110000.0	100.0
Pipe	piece	2.0	20000.0	40000.0	100.0
Branches for trellising	piece	225.0	300.0	67500.0	100.0
Small water tank	piece	2.0	6000.0	12000.0	100.0
Total costs for establishment of the Technology				**633000.0**	

Maintenance activities

1. Weeding (Timing/ frequency: every 2 weeks)
2. Putting cow manure and composting (Timing/ frequency: only a times when plant is 10 to 15 days)
3. Down branches cutting (Timing/ frequency: when plant is 20 to 25 days)
4. DAP, KCL fertilizers putting (Timing/ frequency: 3 times when planting, flowering, and producing)
5. Pesticide preparation (Timing/ frequency: when insects is appeared)

6. Pesticide spreading (Bug, houseplant, wasp) (Timing/ frequency: spread when insects are appeared)

Total maintenance costs (estimation)
400000.0

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☐ sub-humid
- ☑ semi-arid
- ☐ arid

Specifications on climate
Average annual rainfall in mm: 1209.0
The annual rainfall in 2015 is 1209 mm. In 2014 is 1420.74 mm and in 2013 is 1367.5 mm
Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)

Slope
- ☑ flat (0-2%)
- ☐ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☑ plateau/plains
- ☐ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☑ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☐ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☑ very deep (> 120 cm)

Soil texture (topsoil)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☑ coarse/ light (sandy)
- ☐ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Topsoil organic matter content
- ☐ high (>3%)
- ☑ medium (1-3%)
- ☐ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☑ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☑ good
- ☐ medium
- ☐ poor/ none

Water quality (untreated)
- ☑ good drinking water
- ☐ poor drinking water (treatment required)
- ☐ for agricultural use only (irrigation)
- ☐ unusable

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☐ Yes
- ☑ No

Species diversity
- ☐ high
- ☐ medium
- ☐ low

Habitat diversity
- ☐ high
- ☐ medium
- ☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☑ mixed (subsistence/ commercial
- ☐ commercial/ market

Off-farm income
- ☐ less than 10% of all income
- ☑ 10-50% of all income
- ☐ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☐ poor
- ☐ average
- ☑ rich
- ☐ very rich

Level of mechanization
- ☑ manual work
- ☐ animal traction
- ☐ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative
- ☐ employee (company, government)

Gender
- ☐ women
- ☑ men

Age
- ☐ children
- ☐ youth
- ☐ middle-aged
- ☑ elderly

Area used per household
- ☐ < 0.5 ha
- ☐ 0.5-1 ha
- ☑ 1-2 ha
- ☐ 2-5 ha
- ☐ 5-15 ha
- ☐ 15-50 ha
- ☐ 50-100 ha
- ☐ 100-500 ha
- ☐ 500-1,000 ha
- ☐ 1,000-10,000 ha
- ☐ > 10,000 ha

Scale
- ☑ small-scale
- ☐ medium-scale
- ☐ large-scale

Land ownership
- ☐ state
- ☐ company
- ☐ communal/ village
- ☐ group
- ☐ individual, not titled
- ☑ individual, titled

Land use rights
- ☐ open access (unorganized)
- ☐ communal (organized)
- ☐ leased
- ☑ individual

Water use rights
- ☐ open access (unorganized)
- ☐ communal (organized)
- ☐ leased
- ☑ individual

Access to services and infrastructure

health	poor ☐ ☑ ☐ good

education	poor		✓		good
technical assistance	poor			✓	good
employment (e.g. off-farm)	poor	✓			good
markets	poor	✓			good
energy	poor	✓			good
roads and transport	poor		✓		good
drinking water and sanitation	poor			✓	good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased						✓		increased	After using animal manure and compost
risk of production failure	increased						✓		decreased	
product diversity	decreased						✓		increased	
farm income	decreased						✓		increased	Soil is less compact and more rich in nutrients, which increases the production and therefore also the farm income.
diversity of income sources	decreased							✓	increased	More plant types can be planted, which diversifies the income sources.
economic disparities	increased						✓		decreased	Before the farm family was poorer, as they had difficulties to plant their sandy soil area. The improvement of this land improved also the livelihood of this family.
workload	increased						✓		decreased	Reduced workload by using drip system and anise basil plantation, which reduces weed growing and pests.

Socio-cultural impacts

food security/ self-sufficiency	reduced							✓	improved	By getting fresh vegetables and daily income
health situation	worsened							✓	improved	Never face with healthy
land use/ water rights	worsened				✓				improved	Are the same like before
recreational opportunities	reduced						✓		improved	After retired from government official, he just practices agriculture to reduce free time and to exercise.
SLM/ land degradation knowledge	reduced							✓	improved	

Ecological impacts

water quantity	decreased				✓				increased	Water quantity is enough for plantation.
water quality	decreased					✓			increased	No chemical fertilizer is applied, which results in better water quality.
excess water drainage	reduced						✓		improved	Using drip irrigation system, which saves water.
soil moisture	decreased						✓		increased	More crop as soil cover to improve soil moisture. And the manure in the soil improves it too.
soil cover	reduced							✓	improved	Before the soil was left uncultivated.
soil compaction	increased						✓		reduced	Reduced soil compaction by using animals manure and composting. This improves the soil structure.
nutrient cycling/ recharge	decreased						✓		increased	Using animals manure and composting
soil organic matter/ below ground C	decreased						✓		increased	Using animals manure and compost before each plantation time.
vegetation cover	decreased							✓	increased	Before could not grow even water morning glory but now could grow many crops to reduced soil erosion.
plant diversity	decreased						✓		increased	Planting many crops and exchange crops types.
invasive alien species	increased					✓			reduced	Using smelling crops such as anise basil. But it could be reduced only partly.
beneficial species (predators, earthworms, pollinators)	decreased						✓		increased	More earthworm in the soil
pest/ disease control	decreased					✓			increased	

Could reduce some due to the smelling crops underneath.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐ ☐ ☐ ☐ ✓ ☐ ☐	very positive
Long-term returns	very negative	☐ ☐ ☐ ☐ ☐ ✓ ☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐ ☐ ☐ ☐ ☐ ✓ ☐	very positive
Long-term returns	very negative	☐ ☐ ☐ ☐ ☐ ✓ ☐	very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes			
Gradual climate change				
annual temperature increase	not well at all	☐ ☐ ☐ ✓ ☐	very well	
annual rainfall	not well at all	☐ ☐ ☐ ☐ ☐	very well	Answer: not known
Climate-related extremes (disasters)				
heatwave	not well at all	☐ ☐ ☐ ✓ ☐	very well	
epidemic diseases	not well at all	☐ ☐ ☐ ✓ ☐	very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☑ single cases/ experimental
☐ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Increased household incomes
- No negative health impacts because no application of chemical fertilizers or pesticides
- Help to reduce the import of crops

Strengths: compiler's or other key resource person's view

- Reduce some insect pests because of the strong aromatic nature of some crops such as anise basil and spring onion
- Improving soil fertility through the rotation of crops and the use of animal manure and compost
- Increase household income and provide easy-to-sell products

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- There are some insects → Apply botanical pesticides produced by the farmer from some plants

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

REFERENCES

Compiler
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Date of documentation: July 18, 2017

Last update: Dec. 28, 2017

Resource persons
Chan Phally (phallychanagronomy@yahoo.com) - land user
Chhim Bunleang (chhimbunleang@gmail.com) - Vice Chief of Agronomy Office at District Office of Agriculture, Forestry and Fisheries, Rolea B'ies
Sombo Khim (khimsombo79@gmail.com) - Vice Chief of Extension Office of Provincial Department of Agriculture, Forestry and Fisheries, Kampong Chhnang Province
Se Keo (keo.se2017@gmail.com) - Chief of District Office Agriculture, Forestry and Fisheries, Tuek Phos

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_2949/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

Key references

- Yang S. and Pean S. (2015) Kit of Simple Agriculture Technologies. CEDAC.: Can find out at CEDAC, cost 10000 riel

Links to relevant information which is available online

- Rhoades H. (2016) Sandy Soil Amendments: How to do sandy soil improvement. Gardening. : Retrieved on July 18 from: https://www.gardeningknowhow.com/garden-how-to/soil-fertilizers/amending-sandy-soil.htm

Brick compost basins for making compost (Mr. Tim Sophea)

Using dry compost on paddy rice fields (Cambodia)

Dry composting

DESCRIPTION

Dry compost is made from raw materials of cow manure, rice straw, rice husks, ash, leaves, waste from kitchen and water for application on paddy rice field to improveof soil quality and reduce chemical fertilizers.

Compost is a natural fertilizer derived from decayed organic materials, which helps plants grow better than using fresh manure or fresh vegetable residues because they are made up of many organic substances. Farmer could make compost within different periods, short term, medium term and long term. Compost can already be done in 14 to 18 days and it can be used, but the average maturation is 3-4 months and the long term , it can be used after 5 to 6 months (CEDAC, 2015).

Compost is made of manure (cow, buffaloes, pigs, poultry), household waste, fresh plant leaves (woody herb, water hyacinth, water lettuce, vegetable or fruit), etc. The compost brings significant benefits, such as: It provides quick nutrients to plants when compared with fresh manure or unburnt fertilizers. In addition, compost fertilizers bring many microorganisms to the soil, and these organisms help soil fertility. It doesn't exist any plants seed or weed, virus, disease on crop because most of them are killed while the fertilizer is decaying (CEDAC, 2015,YouTube, 2016).

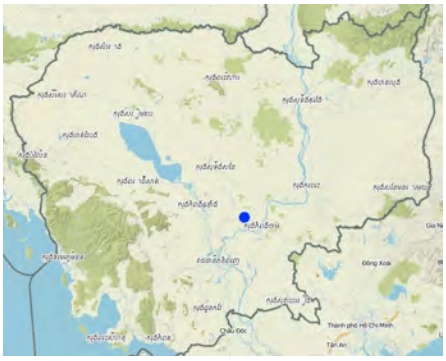
Mr. Mam Mok, the examined farmer of this case study has been practicing this kind of fertilizer since 2008. His compost is made up of ingredients such as rice straw, cow manure, leaves, rice husks, biochar, kitchen waste, water etc. He uses dry compost mainly for his paddy rice fields.

The main purposes of making compost are to increase the rice yield and to get healthier produced rice (reduction in chemical fertilizer). Before he used dry compost his rice yield reached an amount of 4 tons per hectare by using a high amount of Urea (5 bags per hectare), now, though, his yield is about 5 to 6 tons per hectare. In addition, chemical fertilizer has been reduced to 1 to 2 bags per hectare. This means that the application of dry compost reduces as well the expenditure for chemical fertilizers. Another advantage is that the land user gets his manure on-site without spending money, as the most part of material can be found for free on his farm or nearby.

It is a very good SLM technology to improve soil fertility. The application of dry compost avoids compaction, increases the organic matter in soil, boosts the general activity of micro-organisms, and consequently stimulates the growth of rice plants. Then again, there are also some constraints as the amount of compost is not sufficient to feed the whole area of 1.30 hectares. Therefore, every year the farmer spreads the compost only on about an area of 0.50-0.60 hectares by shifting every year the application area. Moreover, the manufacturing requires labor force, which in the family of Mr. Mam Mok is rather decreasing. The duty consists e.g. of collecting raw material and the daily control over compost stage during the maturation process. At any time he has to control if water has to be added to the raw material. After three month he has to transfer the whole compost, partly decayed, from one basin to another, where final maturation takes place. However, the farmer is satisfied with the technology and because of multiple benefits he does not intend to give it up.

Before getting started with compost manufacturing, two compost basins (4 meter in length, 1 m in wide, 1 m in depth) have to be constructed. They are made of bricks, which

LOCATION



Location: Vat Chas village, Chrey Vien commune, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 105.25187, 12.0946

Spread of the Technology: applied at specific points/ concentrated on a small area

Date of implementation: 2008

Type of introduction

☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☑ through projects/ external interventions

guarantee a long life cycle. During the rainy season, the farmer uses a tent to cover the basins.
Following steps are necessary to get dry compost: Step 1: A layer of 30 cm of rice straw squashed and mixed with rice husks has to be filled on the bottom of the first basin. After, this mixture needs to be watered sufficiently. Step 3: 20 cm of cow manure has to be put over the first layer. After this, ash from rice husks or from the kitchen waste has to be added. Then it should be watered again. Last step is to bring the already pre-shredded woody herb or leaves (30 cm) on the previous layer. Preparation of layers takes place at the same time. It can be done at any time given, depending nothing but on available raw material and the labor force supporting the manufacturing.


The person at right side is afarmer who produces dry compost in Vat Chas village. (Mr. Tim Sophea)


Rice straw as raw material for making compost in Vat Chas village (Mr. Tim Sophea)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☑ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☑ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☐ create beneficial economic impact
☐ create beneficial social impact

Land use

Cropland - Annual cropping
Main crops (cash and food crops): Paddy rice

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 1
Land use before implementation of the Technology: Previously high amount of chemical fertilizer was used together with a little of cow manure.
Livestock density: The farmer has 5 cows.

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

physical soil deterioration - Pc: compaction

biological degradation - Bl: loss of soil life

SLM group

- integrated soil fertility management
- waste management/ waste water management

SLM measures

agronomic measures - A2: Organic matter/ soil fertility

TECHNICAL DRAWING

Technical specifications

There are twin compost basins. Each basin is 4 square meters (1 meter width and 4 meters length) for making compost, with 1 meter depth for both basins. There are four holes at the lower parts of the walls. The basins are made of brick with concrete, built closed to the house. The raw material for making compost includes cow manure, leaves, rice husk, ash wash from house and water.

Author: Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology unit
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 25000 KHR

Most important factors affecting the costs

The farmer is not in the situation to pay for external manpower, which means working hard by himself. Another financial constraint consists in bringing up enough money to keep an adequate amount of cows to provide sufficient manure for compost manufacturing.

Establishment activities

1. Constructing compost basins (Timing/ frequency: May)
2. Collecting raw materials (Timing/ frequency: August)
3. Applying ash of rice husk (Timing/ frequency: August)

Establishment inputs and costs

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Construction of compost basins	Day	4.0	15000.0	60000.0	100.0
Fertilizers and biocides					
Cow manure	Two wheel tractor	5.0	300000.0	1500000.0	100.0
Construction material					
Brick	piece	900.0	140.0	126000.0	
Cement	bag	6.0	20000.0	120000.0	
Sand	cubic meter	2.0	40000.0	80000.0	
Atarpaulin	set	1.0	40000.0	40000.0	
Hoe	piece	1.0	15000.0	15000.0	100.0
Handled bansket	pairs	1.0	4000.0	4000.0	
Big knife	piece	1.0	15000.0	15000.0	100.0
Ax	piece	1.0	10000.0	10000.0	100.0
Total costs for establishment of the Technology				**1970000.0**	

Maintenance activities

1. Watering (self-implemented) (Timing/ frequency: Dry season)
2. Transfer from one composting basin to another when it is decompose (Timing/ frequency: Every two moths or threes months and need to control.)
3. Add more compositing materials (Timing/ frequency: Once per 3 months)

Total maintenance costs (estimation)

200000.0

NATURAL ENVIRONMENT

Average annual rainfall

☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☑ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm

Agro-climatic zone

☐ humid
☑ sub-humid
☐ semi-arid
☐ arid

Specifications on climate

Average annual rainfall in mm: 1095.3

The annual rainfall is 1095.3 mm in 2015, 1322.1 mm in 2014, and 1466.9 mm in 2013.

Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)

☐ > 4,000 mm

Slope
☑ flat (0-2%)
☐ gentle (3-5%)
☐ moderate (6-10%)
☐ rolling (11-15%)
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☐ steep (31-60%)
☐ very steep (>60%)

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☐ on surface
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☐ 5-50 m
☐ > 50 m

Availability of surface water
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☐ medium
☐ poor/ none

Water quality (untreated)
☐ good drinking water
☑ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☑ Yes
☐ No

Species diversity
☐ high
☑ medium
☐ low

Habitat diversity
☐ high
☐ medium
☑ low

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☐ very rich

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☑ manual work
☐ animal traction
☐ mechanized/ motorized

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☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☐ women
☑ men

Age
☐ children
☐ youth
☐ middle-aged
☑ elderly

Area used per household
☐ < 0.5 ha
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Scale
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☑ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled
☑ Rental land

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☑ leased
☑ individual

Water use rights
☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor			✓	good
education	poor			✓	good
technical assistance	poor			✓	good
employment (e.g. off-farm)	poor	✓			good
markets	poor			✓	good
energy	poor	✓			good
roads and transport	poor			✓	good
drinking water and sanitation	poor		✓		good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased							✓	increased	Quantity before SLM: 4 tons/hectare Quantity after SLM: 5-6 tons/hectare
crop quality	decreased							✓	increased	Quantity before SLM: 40%

Quantity after SLM: 80%
Good health of crop, when compost was used and soil moisture was improved.

risk of production failure	increased	☐☐☐☐☐✓☐	decreased	The production failure has been reduced because he could produce better crop quality which low input of chemical fertilizer and by meeting the high market demand. His rice which cultivation by using compost can be selled at high prices. For example: Phkar Romdul Rice Variety could be sold at the higher price of 1500 Riel/kg, but if he use much of chemical fertilizer, he can sell it only about for 1000 Riel/kg.
expenses on agricultural inputs	increased	☐☐☐☐☐☐✓	decreased	Raw materials such as cow manure, rice straw, ash are collected in his own farm, and other materials could be found in the region without expense of money.
farm income	decreased	☐☐☐☐☐✓☐	increased	Because of the significant higher yield.
workload	increased	☐☐✓☐☐☐☐	decreased	

Socio-cultural impacts

food security/ self-sufficiency	reduced	☐☐☐☐☐✓☐	improved	Because of better rice yield.
health situation	worsened	☐☐☐☐☐✓☐	improved	The better crop quality with low input of chemical fertilizer which is good for the health.
SLM/ land degradation knowledge	reduced	☐☐☐☐☐✓☐	improved	How to produces compost for reduction of soil degradation. The soil gets less compact and and microorganism in the soil such as earthworm incrases .

Ecological impacts

water quantity	decreased	☐☐☐✓☐☐☐	increased	
water quality	decreased	☐☐☐☐✓☐☐	increased	Less chemical fertilizer led to a positiv impact on water quality.
soil moisture	decreased	☐☐☐☐☐✓☐	increased	The farmer - after using the compost - noticed it when he worked the soil.
soil crusting/ sealing	increased	☐☐☐☐☐✓☐	reduced	Improved soil texture and soil structure.
soil compaction	increased	☐☐☐☐☐✓☐	reduced	As microorganisms activity could be rised, the soil got less compact
nutrient cycling/ recharge	decreased	☐☐☐☐☐✓☐	increased	Compost is rich of earthworm.
soil organic matter/ below ground C	decreased	☐☐☐☐☐✓☐	increased	Increase soil organism to the soil such as earthworm, snails, frog, ant, spiders, termites etc.
plant diversity	decreased	☐☐☐☐☐✓☐	increased	The dry compost provides benefit to every rice species. For example: Growing Phkar Rumduol rice variety or Raiang Chey, the crop are good and get high yield.
beneficial species (predators, earthworms, pollinators)	decreased	☐☐☐☐☐✓☐	increased	Increase such as earthworms, snail , ant , termites etc.

Off-site impacts

damage on neighbours' fields	increased	☐☐☐✓☐☐☐	reduced

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐☐☐✓	very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes

Gradual climate change								
annual temperature increase	not well at all				✓		very well	
annual rainfall decrease	not well at all			✓			very well	
seasonal rainfall increase	not well at all				✓		very well	Season: wet/ rainy season
Climate-related extremes (disasters)								
epidemic diseases	not well at all			✓			very well	
insect/ worm infestation	not well at all			✓			very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology
☐ single cases/ experimental
☐ 1-10%
☑ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?
☐ 0-10%
☑ 10-50%
☐ 50-90%
☐ 90-100%

Number of households and/ or area covered
There are 15 families practicing this technology in the village.

Has the Technology been modified recently to adapt to changing conditions?
☑ Yes
☐ No

To which changing conditions?
☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)
☑ Improve soil fertiity

15 families practices this technology supported by ERECON, however even if the project is finished, the farmers still practice this technology.

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view
- The soil is less compact, because of the improvement ofsoil texture.
- Reduction in the amount of chemical fertilizer.
- Raw materials for composting, which can be found in the village

Strengths: compiler's or other key resource person's view
- Compost provides microorganisms tothe soil, which makes it less compact and easier for the plants to absorb the nutrients.
- Reduction in expenditure on chemical fertilizers, which improves the farmer's livelihood and enables him to use a safer product.
- The farmer has his own cows, rice straw, rice husks and other materials which can be found in the region without need to spend money.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome
- A lack of labor for compost processing in order to complete tasks such as finding adequate material. → step-by-step
- If one does not work hard on this compost, it will not get ready to use. → Check and take care of the composting process.
- Due to rain water the compost gets to much moisture some times. → Placing a plastic tarp sheet over the top.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome
- It requires a lot of labor and time while the family members who were able to assist decreased in number. → Work hard and be patient.
- Making compost also requires proper training because if compost is produced by the farmers themselves without having received instructions or they have learned it from other farmers it might be not of a very high quality. → Promote training or on-farm practices
- Lack of adequate amount of compost for all rice fields. → Rotate application of compost on rice fields.

REFERENCES

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Date of documentation: Oct. 13, 2017

Last update: Dec. 18, 2017

Resource persons
Mok Morm (n/a) - land user
Lieng Song Oem (n/a) - Chief of District Office of Agriculture, Forestry and Fisheries, Prey Chhor

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_3215/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

Key references

- CEDAC. (2015). Kit of simple Agriculture Technologies. Phnom Penh.: Cambodian Center for Study and Development in Agriculture (CEDAC). 10000 Riels

Links to relevant information which is available online

- Video. Compost fertilizer, Cambodia. June 6, 2017:
  https://video.search.yahoo.com/search/video;_ylt=A0LEVzNzS.BZYvMAdaJXNyoA;_ylu=X3oDMTEyNWNiaW4yBGNvbG8DYmYxBHBvcwMxBHZ0aWQDQjI5NDRfMQRzZWMDc2M-?p=Making+dry+compost+in+cambodia&fr=tightropetb#action=view&id=4&vid=62cb521e7ee9d4cda885eb335043bb32

Technique for lettuce cultivation (Ms. Chea Navin)

Cultivation of organic vegetables to improve the household economy and the soil quality (Cambodia)

Organic vegetable farming

DESCRIPTION

Cultivation of mixed organic vegetables utilizing natural fertilizers and homemade pesticides so as to reduce expenditure on external agriculture inputs, as well as produce organic vegetables that safeguard both the producers' and consumers' health. This practice is mainly suitable for the maintenance and improvement of the soil's fertility.

Cultivation of mixed organic vegetables or agriculture based on natural principles is a system which utilizes raw materials, including green plants, animal manure, farm wastes as well as medical plants. All of these materials can be found locally. It avoids the use of any chemical substances or insecticides for the elimination of insects. The implementation of this technology ensures the health of humans, animals, and organisms living in the soil, thereby also securing the soil's fertility. Moreover, it helps to improve the household economy by reducing the costs of buying chemical fertilizers and other materials (MAFF, 2012, MoEYS & VVOB Cambodia, 2013, Social Compass, 2017).

Ms. Teav Chat is one of the farmers growing organic vegetables who was selected to be interviewed for this case study. She has won the national award of best farmer in the production of organic vegetables. She lives in Thma Reab village, Pongro commune, Rolea B'ier district, Kompong Chhnang province, Cambodia. The production of mixed organic vegetables has been implemented since 2004, under the initiative of the Cambodia Center for Study and Development in Agriculture (CEDAC). Around her house she currently grows vegetables on 0.70 ha of land. During the study, she was cultivating mixed organic vegetables including lettuce, cucumbers, yard-long beans, Chinese mustard, pok choi, choy sum, morning glory, spring onions, luffa gourds, wax gourds, holy basil, sweet basil, lemon grassand okra. The most important vegetables out of this group are lettuce, cucumbers, yard-long beans, cabbage vegetables, morning glory and spring onions.

The fundamental components of this technology are the production, and utilization of natural fertilizers (cow manure, dry compost and liquid compost), the combination of medical plants containing natural poisons to combat pests, a natural irrigation source (such as digging a well or a pond), multi cropping, intercropping, as well as crop rotation. As she raises cows, only cow manure is used as fertilizer. Dry compost is made from fresh manure, the leaves of woody herbs or other green leafed plants, rice straw and biochar. Then, the liquid compost is mixed with cow manure, woody herbs, fish heads, boraphed, and cow's urine. Remarkably, the farmer places these ingredients mixed together with cow's urine that is collected daily without addition of water. Regarding the production of insecticide, she created a mixture of chili, galangal, together with the leaves or shells of the downy thorn apple.

The main purpose of this technology is to obtain mixed organic vegetables and generate a more regular household income by also reducing the expenses involved in buying chemical fertilizers and pesticides. In other words, organic vegetables have a solid domestic market, consisting of home-based buyers, and so the farmer spends less time for selling her production. The crop diversification respectively mixed organic vegetables supports the farmer also in reducing the exposure to market fluctuations. This means that she should have a wide range of organic vegetables in order to supply the market

LOCATION

Location: Rural area, Thma Reab village, Pongro Commune, Rolea B'ier District, Kampong Chhnang Province., Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 104.5785, 12.2729

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

Date of implementation: 2004

Type of introduction

☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☑ through projects/ external interventions

during all seasons, thereby being able to generate an income throughout the year. In this way the farmer earns a net income 3,330,000 Riel per year. Beside this, the cultivation of organic vegetables using natural fertilizers improves the soil's fertility. In this way the soil gets rich in microorganisms such as earth worms and other micro-organisms (bacteria or fungi) which play a vital role in decaying organic matter which transform into nutrients for the plants.

In this case study, the natural fertilizer cow manure was used whilst drying the soil in the field or when ploughing the soil in order to expose it. The dry compost is generally applied at the base of the crop roots when the vegetable are planted. Furthermore the liquid compost is used as a fertilizer once the crop begins to grow by irrigating it every three days in the evenings. About 100 ml of liquid compost is mixed with 10 liters of water in order to irrigate the rows with a width of 0.5 meters and a length of 10 meters. For regular maintenance, the fertilizer is added to each of the vegetable crops depending also on the quantity of natural fertilizer that is available. Natural pesticides are also used to ward off insects or to prevent them from destroying the crop.


View of holy basil and luffa gourds cultivation (Ms. Chea Navin)


Cultivation of organic vegetables by plots (Ms.Chea Navin)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☐ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☑ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☑ create beneficial social impact

Land use

Cropland - Annual cropping
Main crops (cash and food crops): The farmer cultivatec main crops, such as lettuce, cabbage, morning glories and yard-long beans.

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 3
Land use before implementation of the Technology: n.a.
Livestock density: n.a.

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

biological degradation - Bl: loss of soil life, Bp: increase of pests/ diseases, loss of predators

SLM group

- integrated soil fertility management
- integrated pest and disease management (incl. organic agriculture)
- home gardens

SLM measures

agronomic measures - A2: Organic matter/ soil fertility, A6: Others

TECHNICAL DRAWING

Technical specifications

The technology is being applied on 0.70 hectares of land. The wide range of organic vegetables include lettuce, cucumbers, yard-long beans, Chinese mustard, pok choi, choy sum, morning glory, spring onions, luffa gourds, wax gourds, holy basil, sweet basil, lemon grass, okra, Edible Amaranth and Green Amaranth. This cultivation practice applies natural fertilizers, including cow manure, dry compost, liquid compost, and insecticide made of medicinal plants containing natural poisons. For irrigation purposes there is a pond which measures 10 meters in length, 6 meters in width and 4 meters in depth and also a well with a depth of 10 meters. The cow shed is 24 square meters, housing a herd of 6 cattle.

Author: Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **0.70 ha**)
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 20000 Riel

Most important factors affecting the costs

The farmer has to change the bamboo construction as it lasts only for 2 years.

Establishment activities

1. Bring the soil on the implementation area (Timing/ frequency: During the dry season)
2. Soil preparation (Timing/ frequency: During the dry season)
3. Make shelter for planting the seedlings (Timing/ frequency: 1 day)
4. Building house for dry compost (Timing/ frequency: 1 day)
5. Buying the jar for making the liquid compost (Timing/ frequency: 1 day)

Establishment inputs and costs (per 0.70 ha)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Bring the soil on the implementation area	person-day	3.0	20000.0	60000.0	100.0
Soil preparation	person-day	6.0	20000.0	120000.0	100.0
Make shelter for planting crop	person-day	1.0	20000.0	20000.0	100.0
Building house for dry compost	person-day	1.0	20000.0	20000.0	100.0
Equipment					
Watering cans	pair	4.0	25000.0	100000.0	100.0
Spade	piece	1.0	20000.0	20000.0	100.0
Hoe	piece	2.0	25000.0	50000.0	100.0
Pumping machine	set	1.0	800000.0	800000.0	100.0
Plant material					
Chinese mustard	package	1.0	2000.0	2000.0	100.0
Morning glory	can	1.0	2000.0	2000.0	100.0
Lettuce	package	1.0	4000.0	4000.0	100.0
Pok choi	package	1.0	2000.0	2000.0	100.0
Choy sum	package	1.0	8000.0	8000.0	100.0
Cucumber	can	1.0	5000.0	5000.0	100.0
Yard-long beans	can	1.0	2000.0	2000.0	100.0
Luffa gourds	can	1.0	2000.0	2000.0	100.0
Construction material					
Net	piece	3.5	28000.0	98000.0	100.0
Bamboo	stem	50.0	5000.0	250000.0	100.0
Other					
Holy basil	package	1.0	2500.0	2500.0	100.0
Okra	package	2.0	2500.0	5000.0	100.0
Sweet basil	package	1.0	2500.0	2500.0	100.0
Corn	kg	1.0	4500.0	4500.0	100.0
Total costs for establishment of the Technology				**1579500.0**	

Maintenance activities

1. Soil preparation for vegetable cultivation (Timing/ frequency: 6 days)
2. Seedling transplantation (Timing/ frequency: 3 days)
3. Watering (self-implemented) (Timing/ frequency: everyday)
4. Apply the liquid compost (Timing/ frequency: Once per 3 days)
5. Weeding (Timing/ frequency: every day)

Maintenance inputs and costs (per 0.70 ha)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Soil preparation for vegetables cultivation	person-day	6.0	20000.0	120000.0	100.0
Seedling transplantation	person-day	3.0	20000.0	60000.0	100.0
Weeding	person-day	15.0	20000.0	300000.0	100.0
Irrigating the liquid compost	person-day	3.0	20000.0	60000.0	
Equipment					
Repair equipment to repair the water pumping machine	set	1.0	260000.0	260000.0	100.0
Fertilizers and biocides					
Biochar	bag	10.0	1000.0	10000.0	100.0
Cow manure	kg	10.0	250.0	2500.0	100.0
Woody herbs	kg	10.0	600.0	6000.0	100.0
Total costs for maintenance of the Technology				818500.0	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate

In 2015, the annual rainfall was 1209 mm
In 2014, the annual rainfall was 1420.74 mm
In 2013, the annual rainfall was 1367.5 mm
Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)

Slope
- ☑ flat (0-2%)
- ☐ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☑ plateau/plains
- ☐ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☑ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☐ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☑ very deep (> 120 cm)

Soil texture (topsoil)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Topsoil organic matter content
- ☑ high (>3%)
- ☐ medium (1-3%)
- ☐ low (<1%)

Groundwater table
- ☐ on surface
- ☑ < 5 m
- ☐ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☑ good
- ☐ medium
- ☐ poor/ none

Water quality (untreated)
- ☑ good drinking water
- ☐ poor drinking water (treatment required)
- ☐ for agricultural use only (irrigation)
- ☐ unusable

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☐ Yes
- ☑ No

Species diversity
- ☐ high
- ☐ medium
- ☑ low

Habitat diversity
- ☐ high
- ☐ medium
- ☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☑ mixed (subsistence/ commercial
- ☐ commercial/ market

Off-farm income
- ☑ less than 10% of all income
- ☐ 10-50% of all income
- ☐ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☐ poor
- ☑ average
- ☐ rich
- ☐ very rich

Level of mechanization
- ☐ manual work
- ☐ animal traction
- ☑ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative
- ☐ employee (company, government)

Gender
- ☑ women
- ☐ men

Age
- ☐ children
- ☐ youth
- ☐ middle-aged
- ☑ elderly

Area used per household
☐ < 0.5 ha
☑ 0.5-1 ha
☐ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☐ small-scale
☑ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☑ communal/ village
☐ group
☐ individual, not titled
☐ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor			✓	good
education	poor			✓	good
technical assistance	poor			✓	good
employment (e.g. off-farm)	poor			✓	good
markets	poor			✓	good
energy	poor	✓			good
roads and transport	poor			✓	good
drinking water and sanitation	poor			✓	good
financial services	poor		✓		good

IMPACTS

Socio-economic impacts

Crop production	decreased						✓		increased	Quantity before SLM: 20% Quantity after SLM: 50%
crop quality	decreased						✓		increased	The farmer uses natural fertilizer such as compost (liquid and dry) that soil rich nutrient to make crop growing well and she uses botanical pesticide to prevent insect for getting good crop quality.
risk of production failure	increased						✓		decreased	The farmer has a very professional knowledge on organic vegetable growing through the participaton of the training by CEDAC and through her broad own expericence since 2004. This helped to reduce the risk of production failure to a minimum.
product diversity	decreased						✓		increased	She has cultivated a broad variety of organic vegetables so as she increased the production for the household consumption and for the market demand.
land management	hindered						✓		simplified	The farmer uses natural fertilizer to improve soil quality and the different crop are absorb different nutrition from soil. On the other hand, crop help to reduce soil erosion.
expenses on agricultural inputs	increased						✓		decreased	The farmer did not spend much money to external agricultural inputs due to getting the raw material for organic vegetable farming in her surroundings.
farm income	decreased							✓	increased	First of all she increased the production and accordingly she was also able to increase her income. Then also she was able to reduce the exposure to market price fluctuations because she is connected to a solid domestic market, consisting of home-based buyers. By this she spend not only less time for selling her products also she is getting always very solid or even higher prices for these species of organic vegetables.
workload	increased			✓					decreased	In her family need to spend more time for work in farming like the maintenance activities on crops, making compost (dry and liquid) and botanical pesticide.

Socio-cultural impacts

food security/ self-sufficiency	reduced							✓	improved	The farmer has actually more than enough organic vegetables to meet her own demand during the whole year.

Ecological impacts

soil compaction	increased							✓	reduced	The crops keep the soil moisture and the compost making the soil rich nutrient and microorganism like earth worm which promote the soil aeration.

nutrient cycling/ recharge	decreased	☐☐☐☐☐☐✓	increased	Difference crop can absorb different nutrient and the crop residuals are a supplement fertilizer for the soil.
soil organic matter/ below ground C	decreased	☐☐☐☐☐☐✓	increased	Using compost and cow manure improved the soil fertility and enriched the soil by microorganism so that crop grows well.
beneficial species (predators, earthworms, pollinators)	decreased	☐☐☐☐☐☐✓	increased	This technology promoted many different microorganisms such as for example bacteria and fungi.
pest/ disease control	decreased	☐✓☐☐☐☐☐	increased	The farmer uses botanical pesticide to prevent harmful insects. And the grow of different crops can reduce disease and insects as well.

Off-site impacts

Farmer can produce organic vegetable to provide the consumers with healthy food.	None	☐☐☐☐✓☐☐	None	Because of farmer do not use chemical pesticide and do not use chemical fertilizer for growing crop.

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐☐✓	very positive
Long-term returns	very negative	☐☐☐☐✓☐☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes		
Gradual climate change			
annual temperature increase	not well at all	☐☐☐✓☐	very well
annual rainfall increase	not well at all	☐☐☐✓☐	very well
Other climate-related consequences			
extended growing period	not well at all	☐☐☐✓☐	very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Number of households and/ or area covered
10 households

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- The farmer is able to grow vegetables based on market demand, and mixed organic vegetables are easy to sell, and so it is possible to generate a higher income throughout the whole year.
- The soil is fertile because of the use of natural fertilizer compared with the previous use of chemical fertilizer which caused crusting.
- It is an adaptation to climate change, so that water resources are available for crop irrigation in times of drought.

Strengths: compiler’s or other key resource person’s view

- The farmer obtains organic vegetables for daily household

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Lack of dry compost and liquid compost for vegetables. → Increasing the manufacture of both dry and liquid compost.
- Presence of numerous insects. → Manufacture insecticide from medicinal plants containing natural poisons.

Weaknesses/ disadvantages/ risks: compiler’s or other key resource person’s view → how to overcome

- The farmer met difficulties of implementing the technology in cultivating mixed organic vegetables. → Under the initiative of the Cambodia Center for Study and Development in

consumption and generates an income.
- Improve and maintain the soil's productivity through the use of natural fertilizers.
- Reduce expenditure on external agricultural inputs such as chemical fertilizers and pesticides.

Agriculture (CEDAC).
- A lack of labor to grow and maintain organic vegetables.
  → Use of drip irrigation to save time and labor.

REFERENCES

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Date of documentation: Aug. 23, 2017

Last update: April 23, 2018

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Se Keo - Chief of District Office of Agriculture, Forestry and Fisheries of Tuek Phos

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_3151/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

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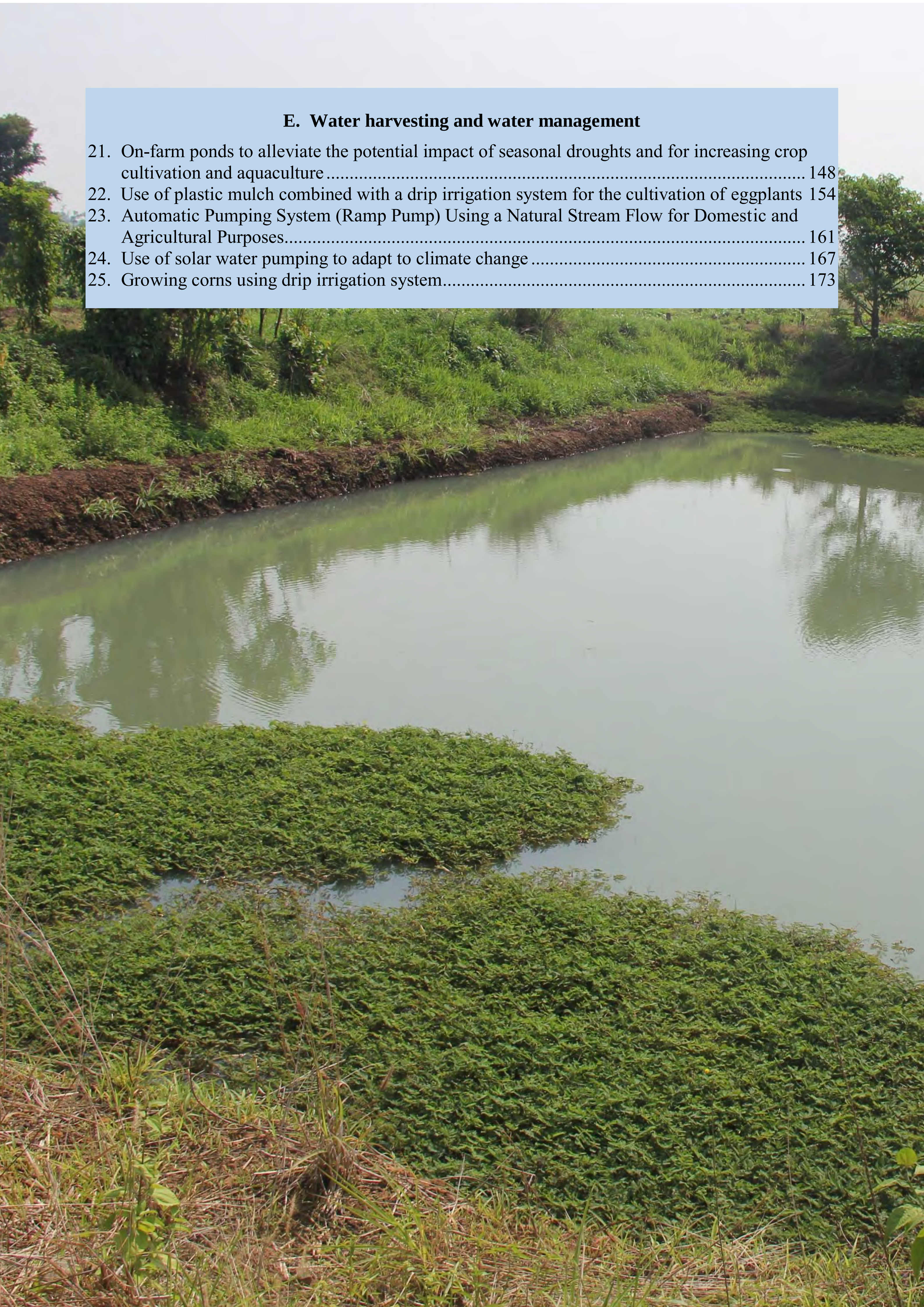


E. Water harvesting and water management

Pond serving for irrigation during drought and for small-scale aquaculture (Mr. Tim Sophea)

On-farm ponds to alleviate the potential impact of seasonal droughts and for increasing crop cultivation and aquaculture (Cambodia)

DESCRIPTION

Digging ponds on farms to harvest rain water used for irrigating crops during drought provides a means for addressing a lack of water at the start of crop cultivation, both before the start of the rainy season and after the end of the rainy season. The main objective of this practice is to increase the duration of the potential growing seasons for crops. A pond with a storage capacity of 2,412 cubic meter of water can potentially irrigate crops year-round in an area of at least 1.6 hectares, including during the dry-season.

In areas with low rainfall and limited or lack of irrigation systems, the harvesting of rainwater for potential irrigation is an important practice for crop cultivation and food security. The amount of water potentially available is also an integral factor that farmers need to take into account. Furthermore, climate change is another pressure for farmers to adapt to, due to the potential adverse impact on agricultural activities, including a reduction in crop yields, increases in the incidence of crop diseases and insect pests, together with more frequent extreme weather events, including irregular rainfall, droughts and floods.

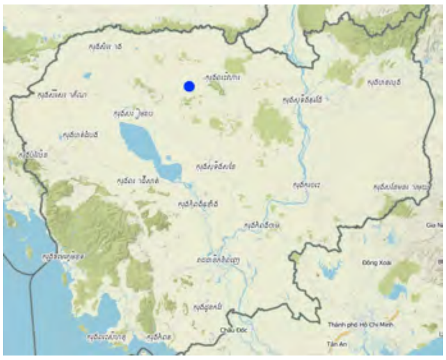
In response to the above issues, farmers have the potential to dig ponds for water storage, and the application of drip irrigation for cropping activities. The development of on-farm ponds provides a crop water resource during drought periods, while also providing opportunities for small-scale aquaculture and vegetable cropping. Having a pond in a field is regarded as being resilient to climate change (climate-smart agriculture) because farmers can have sufficient water for irrigation in all seasons throughout the year.

With the application of drip irrigation, farmers save water and time. Labour input for irrigation is reduced while a better environment is provided for crop growth, reduced soil erosion and better management of weeds, diseases and some insect pests. Drip irrigation is also a system of irrigation that maximizes water use efficiency in periods of drought in response to climate change.

Before making the decision to dig a pond, the farmer had observed and estimated the availability of water resources including the groundwater in the area for around two years by learning from the existing wells of neighbours around his land. The selected point for digging the pond is at the lowest part of his land, and it is also based on the fact he found that the neighbouring pump wells have good source of groundwater. This pond hence collects rainwater and connects to underground water aquifer, which is not very deep.

A farmer may not have to spend money for the digging of a pond on his land, as it is potentially possible to reach an agreement with the owner of an excavator (soil digging machine), to allow the owner of the machine to take the excavated soil in payment for the excavation of the pond. Without such a mutual agreement, the cost to the farmer of digging a pond could be as high as 8 million riel (about US$2,000). A suitable farm pond would need to have surface size of 40 x 20 meters and a bottom size of 29 x 14 meters. A pond depth of 4 meters might potentially provide 2 meters depth of water which can potentially provide sufficient water to irrigate over 1.6 hectares of crop in the dry-season,

LOCATION



Location: Srayang Tboung village, Srayang commune, Kuleaen district, Preah Vihear province, Cambodia

No. of Technology sites analysed: 10-100 sites

Geo-reference of selected sites

- 104.55815, 13.69309

Spread of the Technology: applied at specific points/ concentrated on a small area

Date of implementation: 2013

Type of introduction

☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☐ through projects/ external interventions

thereby enable farmers to grow at least two crops per year (or perhaps four crops that are short maturing). Farmers have also been able to raise at least 600 Tilapia fish (a freshwater fish) in the ponds.

Farmers with access to water from a farm pond are able to grow more crops than previously, get higher yields, and grow crops such as pumpkin in the dry-season due to having access to water for irrigation.

Pumpkin cropping irrigated by water from the pond (Tim Sophea)

Using drip irrigation for irrigating the crop (Tim Sophea)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☐ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☑ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☐ create beneficial economic impact
☑ create beneficial social impact
☑ Can grow crops all year round, including before rainy season

Land use

Waterways, waterbodies, wetlands - Ponds, dams
Main products/ services: Since the excavation of the pond water is always available. Before excavating the pond, the farmer was growing corn, mung beans, and soy beans and was dependent on the rain. Now he can grow pumpkin, also if it doesn't rain. After 3-4 days the farmer starts to pump water from the pond to irrigate the pumpkins.

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 2

Land use before implementation of the Technology: In the past, the land where the crops are grown was forest. The forest was removed, then crops were grown and the soils became less fertile.

Livestock density: n.a.

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion

water degradation - Ha: aridification, Hs: change in quantity of surface water

SLM group

- water harvesting
- irrigation management (incl. water supply, drainage)

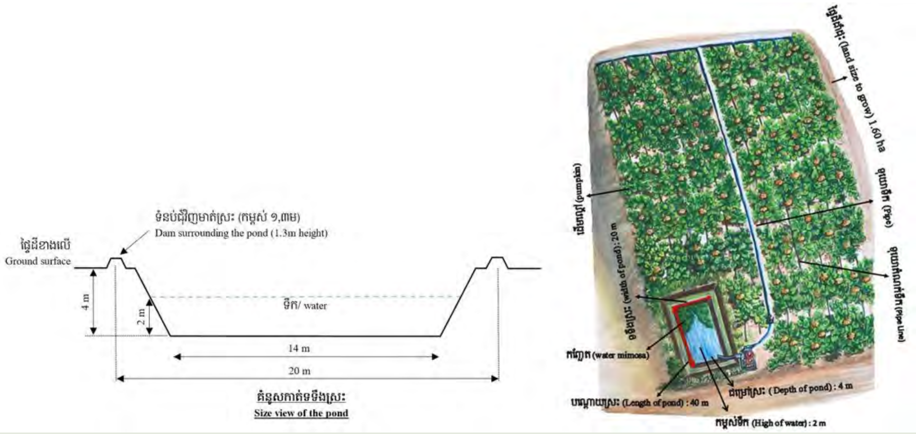
SLM measures

structural measures - S5: Dams, pans, ponds, S7: Water harvesting/ supply/ irrigation equipment

TECHNICAL DRAWING

Technical specifications

Constructed at the lowest part of the land, the pond has a surface size of 40 x 20 meters and bottom size of 29 x 14 meters. The depth is 4 meters with the water level of around 2 meters depth. The water level in the pond remains similar both in dried and rainy seasons. The farmer makes a earth dam around it with 1.3 meters high to protect sedimentation flow into the pond during heavy rainfall. The farmer also plants some local grass surrounding the dam to prevent soil erosion. Some water mimosa was also put in the pond to serves two functions, for filtering the water and as feed for fish in the pond.



Author: Mr. Khoun Sophal and Mr. Tim Sophea

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology unit (unit: **Pond and irrigation system** volume, length: **800 square meters for pond, pipe (main line and sub main line) 220 meters, and tube 500 meters)**
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 20000 Riel

Most important factors affecting the costs

The wage of the excavator for digging the pond is expensive. However, this can be overcome by giving the soil to the excavator who can sell the soil and therewith does the work for free.

Establishment activities

1. Digging pond with excavator (Timing/ frequency: December)
2. Building a dam surrounding the pond (Timing/ frequency: December)
3. Motor pump (Timing/ frequency: December)
4. Set up drip irrigation (Timing/ frequency: February)
5. Plant local grass on the dam and put water mimosa in the pond (Timing/ frequency: May)

Establishment inputs and costs (per Pond and irrigation system)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Digging pond and making dam (by exscavator)	Hour	40.0	200000.0	8000000.0	
Set up drip irrigation	person-day	2.0	40000.0	80000.0	100.0
Equipment					
Motor pump pipe and tube sets for drip irrigation	Set	1.0	2720000.0	2720000.0	100.0
Total costs for establishment of the Technology				**10800000.0**	

Maintenance activities

1. Restore the pond (Timing/ frequency: Dry season)
2. Fixing the dam (Timing/ frequency: No rain)
3. Irrigating the crops (Timing/ frequency: During drought)

Maintenance inputs and costs (per Pond and irrigation system)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Restoring the pond and fixing the dam	person-day	7.0	20000.0	140000.0	100.0
Construction material					
Gasoline for pumping	Liter	30.0	2800.0	84000.0	100.0
Total costs for maintenance of the Technology				**224000.0**	

NATURAL ENVIRONMENT

Average annual rainfall

☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☐ 1,001-1,500 mm
☑ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone

☐ humid
☑ sub-humid
☐ semi-arid
☐ arid

Specifications on climate

Average annual rainfall in mm: 1102.02
The annual rainfall was 1,393 mm, 878.13 mm and 1,102.02 mm, in 2013, 2014 and 2015 respectively.
Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)
There are 2 seasons: dry and rainy seasons

Slope
☐ flat (0-2%)
☐ gentle (3-5%)
☑ moderate (6-10%)
☐ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☑ 0-100 m a.s.l.
☐ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☑ concave situations
☐ not relevant

Soil depth
☐ very shallow (0-20 cm)
☐ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☑ very deep (> 120 cm)

Soil texture (topsoil)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☑ coarse/ light (sandy)
☐ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☑ medium (1-3%)
☐ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☑ good
☐ medium
☐ poor/ none

Water quality (untreated)
☐ good drinking water
☐ poor drinking water (treatment required)
☑ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☐ high
☐ medium
☑ low

Habitat diversity
☐ high
☐ medium
☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☐ mixed (subsistence/ commercial
☑ commercial/ market

Off-farm income
☑ less than 10% of all income
☐ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
☐ poor
☑ average
☐ rich
☐ very rich

Level of mechanization
☐ manual work
☐ animal traction
☑ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☐ women
☑ men

Age
☐ children
☐ youth
☑ middle-aged
☐ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☐ 2-5 ha
☑ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☐ small-scale
☑ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled
☑ land rent

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☑ leased
☑ individual

Water use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor			✓	good
education	poor			✓	good
technical assistance	poor	✓			good
employment (e.g. off-farm)	poor		✓		good
markets	poor		✓		good
energy	poor	✓			good
roads and transport	poor	✓			good
drinking water and sanitation	poor		✓		good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased						✓		increased
crop quality	decreased					✓			increased

The farmer can cultivate more crops including pumpkin during the dry season.

The crop is healthier and produces better yields due to the sufficient irrigated water.

risk of production failure	increased	☐☐☐☐☐✓☐	decreased	Have enough water for irrigation during drought
product diversity	decreased	☐☐☐☐✓☐☐	increased	Possible to grow multiple crops
land management	hindered	☐☐☐☐☐✓☐	simplified	Quantity before SLM: soil less moisture Quantity after SLM: soil have more moisture than before The pond provides sufficient water to the land.
drinking water availability	decreased	☐☐☐☐☐✓☐	increased	The water from the pond can be used for drinking after properly boiled.
drinking water quality	decreased	☐☐☐✓☐☐☐	increased	The water from the pond can be used for drinking after properly boiled.
irrigation water availability	decreased	☐☐☐☐☐☐✓	increased	The pond provides sufficient water in all seasons.
irrigation water quality	decreased	☐☐☐☐☐✓☐	increased	Water from the pond is not mineral contaminated like that pumping directly from a well.
demand for irrigation water	increased	☐☐☐☐☐✓☐	decreased	Growing more crops, but moderating the demand of water due to the use of drip irrigation system.
expenses on agricultural inputs	increased	☐☐☐☐☐✓☐	decreased	Growing more crops and using drip irrigation system.
farm income	decreased	☐☐☐☐☐☐✓	increased	Received good yield of every crop after having enough irrigation water.

Socio-cultural impacts

SLM/ land degradation knowledge	reduced	☐☐☐☐✓☐☐	improved	Growing more crops, the farmer has more knowledge and experience with the practices.

Ecological impacts

water quantity	decreased	☐☐☐☐☐☐✓	increased	The water is available from the pond.
water quality	decreased	☐☐☐☐☐✓☐	increased	The dam and the water mimosa protect water quality in the pond.
harvesting/ collection of water (runoff, dew, snow, etc)	reduced	☐☐☐☐☐☐✓	improved	The pond collects both rainwater and groundwater.
groundwater table/ aquifer	lowered	☐☐☐☐☐✓☐	recharge	The pond links with groundwater aquifer.
soil moisture	decreased	☐☐☐☐☐✓☐	increased	More crops as soil cover and with sufficient irrigated water
soil cover	reduced	☐☐☐☐☐✓☐	improved	More crops in all seasons due to the available irrigated water
soil loss	increased	☐☐☐☐☐☐✓	decreased	More crops in all seasons as vegetation cover
plant diversity	decreased	☐☐☐☐☐☐✓	increased	The water availability is conducive for pants to grow.
drought impacts	increased	☐☐☐☐☐✓☐	decreased	The pond can address the problem of drought as it provides enough water even during drought of the area.

Off-site impacts

damage on neighbours' fields	increased	☐☐☐☐☐✓☐	reduced	Some neighbors also use water from the pond for domestic purposes.

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

Other people are interested to have ponds but they are afraid that the groundwater aquifer is too deep on their land and they then don't have enough water in pond.

-

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☑ single cases/ experimental
☐ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Sufficient water is made available for irrigation of crops
- Crops can be grown outside the period of regular cropping based on rainfall distribution

Strengths: compiler's or other key resource person's view

- Water can be stored for irrigation in the dry season and for use during periods of drought
- Neighbors can be given access to water stored in the ponds
- Small-scale aquaculture becomes potentially possible, with the potential for the cultivation of some aquatic plants as vegetables

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Loss of some land from crop cultivation due to the pond
  → Change to using the land to raise fish
- Need to restore the pond within every two or three years
  → Hire someone to do it
- Digging pond is expensive → Seek collaborate with a partner like the person who owns an excavator for mutual benefits

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- Reduced area of cultivated land → Can change the use of the land to grow some aquatic plants and raise fish
- Digging pond is expensive → Seek some support from a project or NGOs, or collaborate with a partner like the person who owns a excavator for mutual benefits

REFERENCES

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Date of documentation: June 24, 2017

Last update: Jan. 23, 2018

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_2844/

Linked SLM data
n.a.

Documentation was faciliated by
Institution

- Royal University of Agriculture (RUA) - Cambodia

Project

- Scaling-up SLM practices by smallholder farmers (IFAD)

Links to relevant information which is available online

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Eggplants cultivation by using plastic mulches and set the drip irrigation on the row under the plastic. (M.Kim Soben)

Use of plastic mulch combined with a drip irrigation system for the cultivation of eggplants (Cambodia)

HARVEST-drip irrigation system

DESCRIPTION

The cultivation of eggplants by using plastic mulch and a drip irrigation system in order to control weeds, retain soil moisture, save water and reduce labor for maintenance, weeding, watering, and the application of fertilizer for increase production and income.

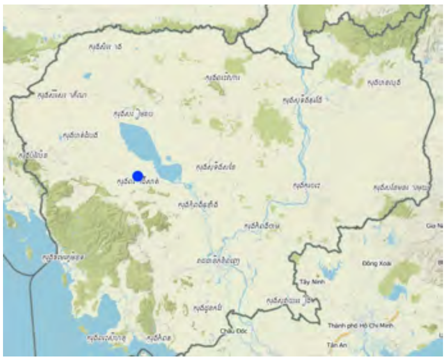
The use of organic materials such as rice straw, water hyacinth, woody herbs, and coconut leaves to retain soil moisture has been practiced by vegetable farmers for many years. Recently, with the availability of diverse industrial products the use of plastic has become a popular technology to cover soils. The impermeable plastic mulch prevents water evaporation. Furthermore condense water built under the impermeable plastic sheets drop back to soil; thus, plastic mulching in combination with the highly efficient drip irrigation substantially saves water for irrigation and it makes it as well suitable to areas faced by water shortage. Generally, black opaque plastic is used, which stops weed growth and in consequences also the attraction of harmful insects. Less weed mean also less competition for soil nutrients and therefore better growth of the crop. Another positive aspect of the weed control is the labor saving otherwise needed for weeding. In addition, plastic mulches play a role in preventing soil erosion and water saturation of the soil. At a nutshell, using plastic mulch combined with drip irrigation saves water for irrigation, reduces the number of harmful insects, and last but not least saves labor and time (FAO, 2017).

The eggplant cultivation in combination with plastic mulch and drip irrigation was introduced by the HARVEST project in 2014. This technology was employed on a farm which formerly grew rice on 1410 square meters of land. The farm comprised 1740 eggplants planted in 20 rows covered by plastic mulch. Eggplant is an annual vegetable plant that matures in well composted soil at temperatures above 20°C. The soil should be kept moist and at the same time water logging has to be avoided.

On the above mentioned farm the technology has been installed as follows: On the already prepared soil (the soil has been ploughed and dried at three separate times) the farmer created a ridge in each row that itself measures 1 meter in width and 20 centimeters in height. The distance between each row was 1 meter. The drip irrigation pipes run along the rows, which were watered after installation. Then, the rows were covered by the plastic mulch at 1.50 meters in width. Next, soil was placed on the plastic sides to hold and protect it against gusts of wind. In order to create a growing space for the eggplants the farmer cut out round windows of 8 cm in diameter along the plastic rows making sure that there is gap of 60 cm) between each window (matches with the holes of the drip irrigation). Finally, eggplant seedlings were planted in the holes. Bamboos sticks near each eggplant provided first support to the seedlings and later on, hold the plants when they are grown and bear fruit.

This technology is economically beneficial as can substantially increase his income. In the interviews the land users reported that without this technology, after deducting the investment and maintenance costs, they generated a net income of only 30%. However, after application of the technology their net income increased up to 70% (as long as the crop was not affected by disease). Furthermore it freed up the farmers' time to fulfill other important tasks.

LOCATION



Location: Chreaeng Village, Svay Luong Commune, Kandieng District, Pursat Province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 103.91749, 12.60218

Spread of the Technology: evenly spread over an area

Date of implementation: 2014; less than 10 years ago (recently)

Type of introduction

☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☑ through projects/ external interventions

Drilled well to get water for applying on crop during drought. (Mr. Kim Soben)

Plastic mulches on eggplant row and drip irrigation pipe under the plastic. (Mr. Kim soben)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☐ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☑ reduce risk of disasters
☑ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use

Cropland - Annual cropping
Main crops (cash and food crops): Eggplant

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 2
Land use before implementation of the Technology: Rice field
Livestock density: There are 5 cows to get manure.

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion

physical soil deterioration - Pw: waterlogging

biological degradation - Bc: reduction of vegetation cover, Bl: loss of soil life

water degradation - Ha: aridification

other -

SLM group

- improved ground/ vegetation cover
- irrigation management (incl. water supply, drainage)

SLM measures

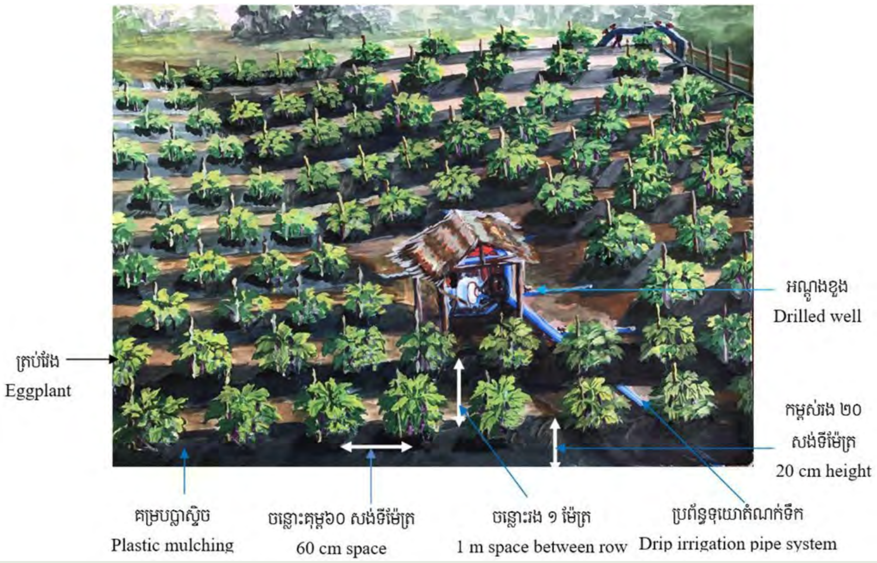
agronomic measures - A2: Organic matter/ soil fertility

structural measures - S4: Level ditches, pits

TECHNICAL DRAWING

Technical specifications

This technology is applied in an area measuring 1410 square meters where 1740 eggplants have been planted in 20 rows. In each row the farmer has created a ridge with a height of 20 cm, and a width of 1 meter, in which the eggplants are planted with a gap of 60 cm between them. All of the rows have a drip irrigation pipe running along the length of the row which is also covered by black plastic sheets of 1.5 meters in width. In the middle of the farm there is one drilled well which has a 1.50 meter house built over the top of it. The land user has also placed three big jars in the middle of the eggplant field with each jar being 1 meter in height and 1 meter in diameter. One of these is for mixing natural fertilizer for the crop, another is for making botanical pesticide and the other one is for water storage. Each eggplant is tied to a bamboo stick to prevent the plant from falling over, when fruits are growing.



Author: Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **1,410 square meters**; conversion factor to one hectare: **1 ha = 0.14 hectare**)
- Currency used for cost calculation: **KHR**
- Exchange rate (to USD): 1 USD = 4000.0 KHR
- Average wage cost of hired labour per day: 20000

Most important factors affecting the costs

Plastic and drip irrigation system are very expensive. The plastic can be used only once and drip irrigation system can be used for 2 years.

Establishment activities

1. Eggplant nursery (Timing/ frequency: April)
2. Planting eggplant in the box produced by banana leaves (Timing/ frequency: May)
3. Plough the soil (Timing/ frequency: May)
4. Make the ridge of the row (Timing/ frequency: May)
5. Apply cow mannure (Timing/ frequency: May)
6. Set up drip irrigation system (Timing/ frequency: May)
7. Watering the rows of crop (Timing/ frequency: May)
8. Cover plastic sheets on the row (Timing/ frequency: May)
9. Planting eggplant (Timing/ frequency: May)

Establishment inputs and costs (per 1,410 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
Plough 3 times	Time	3.0	50000.0	150000.0	100.0
Eggplant nursery	person-day	2.0	20000.0	40000.0	100.0
Make row, apply cow manure, set up drip irrigation system,water on row, plastic mulching.	person-day	5.0	20000.0	100000.0	100.0
Planting eggplant	person-day	2.0	20000.0	40000.0	100.0
Equipment					
Two wheel tractor	Piece	1.0	12300000.0	12300000.0	100.0
Pumping machine	set	1.0	1400000.0	1400000.0	100.0
Hoe	Piece	6.0	12000.0	72000.0	100.0
Spade	Piece	1.0	12000.0	12000.0	100.0
Tent	set	1.0	40000.0	40000.0	
Pesticide sprayer by using hand	Piece	1.0	280000.0	280000.0	
Tray for nursery of eggplant	Piece	30.0	2500.0	75000.0	
Big baskets for harvesting crop	Piece	3.0	15000.0	45000.0	
Plant material					
Eggplant seed	Package	1.0	10000.0	10000.0	
Construction material					
Plastic sheet	set	2.5	70000.0	175000.0	
Drip irrigation system	set	1.5	160000.0	240000.0	
Jar	Piece	3.0	45000.0	135000.0	100.0
Other					
Waterproof boot shoes	Paires	1.0	60000.0	60000.0	
Total costs for establishment of the Technology				**15174000.0**	

Maintenance activities

1. Watering by pumping machine through drip irrigation system (Timing/ frequency: Everyday)
2. Weeding in between of eggplant rows. (Timing/ frequency: Two times in one cycle of crop)

3. Spaying botanical pesticide mixing with pesticides on eggplant (Timing/ frequency: One time per week before first harvesting of eggplant)
4. Apply fertilizer (Timing/ frequency: One time in three days)

Maintenance inputs and costs (per 1,410 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
Weeding between the rows	Time	2.0	240000.0	480000.0	100.0
Fertilizers and biocides					
Golden pesticide	Bottle	1.0	15000.0	15000.0	100.0
Other					
Gasoline for pumping	Liter	70.0	3000.0	210000.0	100.0
Total costs for maintenance of the Technology				**705000.0**	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate
Average annual rainfall in mm: 1225.7
Annual rainfall in 2015 is 1225.7 mm and in 2014 is 1128.1mm and in 2013 is 1316 mm.
Name of the meteorological station: Ministry of Water Resources and Meteorology in 2015

Slope
- ☐ flat (0-2%)
- ☑ gentle (3-5%)
- ☐ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☑ plateau/plains
- ☐ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☑ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☑ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☐ very deep (> 120 cm)

Soil texture (topsoil)
- ☐ coarse/ light (sandy)
- ☐ medium (loamy, silty)
- ☑ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Topsoil organic matter content
- ☐ high (>3%)
- ☑ medium (1-3%)
- ☐ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☑ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☑ good
- ☐ medium
- ☐ poor/ none

Water quality (untreated)
- ☐ good drinking water
- ☐ poor drinking water (treatment required)
- ☑ for agricultural use only (irrigation)
- ☐ unusable

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☑ Yes
- ☐ No

Species diversity
- ☐ high
- ☑ medium
- ☐ low

Habitat diversity
- ☐ high
- ☑ medium
- ☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☐ mixed (subsistence/ commercial
- ☑ commercial/ market

Off-farm income
- ☑ less than 10% of all income
- ☐ 10-50% of all income
- ☐ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☐ poor
- ☑ average
- ☐ rich
- ☐ very rich

Level of mechanization
- ☐ manual work
- ☐ animal traction
- ☑ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative
- ☐ employee (company, government)

Gender
- ☑ women
- ☐ men

Age
- ☐ children
- ☑ youth
- ☐ middle-aged
- ☐ elderly

Area used per household

Scale

Land ownership

Land use rights

☐ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☐ 2-5 ha
☑ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

☐ small-scale
☑ medium-scale
☐ large-scale

☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights

☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor	✓	☐	☐	good
education	poor	☐	☐	✓	good
technical assistance	poor	☐	☐	✓	good
employment (e.g. off-farm)	poor	☐	☐	✓	good
markets	poor	✓	☐	☐	good
energy	poor	✓	☐	☐	good
roads and transport	poor	✓	☐	☐	good
drinking water and sanitation	poor	☐	✓	☐	good
financial services	poor	☐	☐	✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased	☐	☐	☐	☐	☐	✓	☐	increased	The yield of eggplant is increased compared to conventional eggplant plantation (without using plastic mulch in combination with drip irrigation)
crop quality	decreased	☐	☐	☐	☐	☐	✓	☐	increased	The eggplant fruit is bigger and look nicer. In addition, the eggplant provides a lot of fruits.
risk of production failure	increased	☐	☐	☐	☐	☐	✓	☐	decreased	Reduce product failure due to efficiency of water supply and meet the requirement of market that need the product with quality. In addition, she could grow many crops year round. For example: she can use plastic and drip irrigation for growing cucumber, bitter melon etc.
drinking water availability	decreased	☐	☐	☐	✓	☐	☐	☐	increased	Water available from the drilled well.
drinking water quality	decreased	☐	☐	☐	✓	☐	☐	☐	increased	The water require boiling. The water contains corrosion particles.
water availability for livestock	decreased	☐	☐	☐	✓	☐	☐	☐	increased	The water from the drilled well can also be used for cow raising.
irrigation water availability	decreased	☐	☐	☐	✓	☐	☐	☐	increased	There is drilled well to get water for supplying crop during water shortage.
irrigation water quality	decreased	☐	☐	☐	✓	☐	☐	☐	increased	The quality of water is good for growing crop but it contains corrosion particles which affect the drip irrigation system.
demand for irrigation water	increased	☐	☐	☐	☐	☐	✓	☐	decreased	Reduced demand of water by using plastic mulch with drip irrigation system.
expenses on agricultural inputs	increased	☐	✓	☐	☐	☐	☐	☐	decreased	The cost of drip irrigation system and the plastic mulching are expensive. Drip irrigation system can be used for 2 years, but plastic mulch can be used only for one crop cycle.
farm income	decreased	☐	☐	☐	☐	☐	✓	☐	increased	Quantity before SLM: 300,000 Riels Quantity after SLM: 700,000 Riels
diversity of income sources	decreased	☐	☐	☐	✓	☐	☐	☐	increased	Save time to water, apply fertilizer, weeding, so the farmers could have time to do other works such as vegetable selling or rice cultivation.
workload	increased	☐	☐	☐	☐	☐	☐	✓	decreased	The labor for watering and application of fertilizer was reduced. In addition, labor for weeding has been saved substantially. Using plastic mulch combined with a drip irrigation system save labor at about 70%.

Socio-cultural impacts

food security/ self-sufficiency	reduced	☐	☐	☐	☐	☐	✓	☐	improved	The quality of product is good and meet of domestic and market needs. In addition, she could grow other also crops such as cucumber or bitter melon.

SLM/ land degradation knowledge	reduced	☐☐☐☐☐☑☐	improved	Thefamer learned by experience that the soil under the plastic is less compact and the texture looks like compost.

Ecological impacts

soil moisture	decreased	☐☐☐☐☐☑☐	increased	The soil under the plastic can be more easily kept moist.
soil cover	reduced	☐☐☐☐☐☑☐	improved	Plastic mulch sheets serve as soil cover, which reduces evaporation to the atmosphere.
soil crusting/ sealing	increased	☐☐☐☐☐☑☐	reduced	The soil under the plastic sheets is less compact and improves the soil structure.
soil organic matter/ below ground C	decreased	☐☐☐☐☐☑☐	increased	
pest/ disease control	decreased	☐☐☐☐☑☐☐	increased	Weed is a driver of increasing the amount of insect. Plastic mulch, helps to control weed growing.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐☑☐	very positive
Long-term returns	very negative	☐☐☐☐☐☑☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐☐☐☑	very positive
Long-term returns	very negative	☐☐☐☐☐☑☐	very positive

Some farmers who received support from the HARVEST project gave it up when the project finished because of spending too much money on the plastic and drip irrigation system.

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes				
Gradual climate change					
annual temperature increase	not well at all	☐☐☐☑☐	very well	
seasonal temperature increase	not well at all	☐☐☐☑☐	very well	Season: wet/ rainy season
seasonal temperature increase	not well at all	☐☐☐☑☐	very well	Season: dry season

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☑ single cases/ experimental
☐ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☑ 0-10%
☐ 10-50%
☐ 50-90%
☐ 90-100%

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Helps to control weeds.
- Saves labor and time otherwise spent for weeding.
- Saves water by using a drip irrigation system.
- Generates better income for the household.

Strengths: compiler’s or other key resource person’s view

- Weeds are unable to grow, which saves labor on weeding.
- Reduce pest because there not many weed .
- It is easy to maintain and use the drip irrigation system, which saves water and time.
- Retain soil moisture through the use of plastic mulches.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- Establishing this technology costs a lot of money. → Use rice straw instead of plastic mulch.
- Difficult to collect the plastic waste. → Should manage plastic waste properly and set up a place to burn it.

Weaknesses/ disadvantages/ risks: compiler’s or other key resource person’s view → how to overcome

- Spend a lot of money buying plastic mulch and the drip irrigation system. → Seek external support and introduce budget management.
- Plastic and waste from the plastic mulches and drip irrigation

system can have an effect on the environment. → Proper plastic waste disposal.

REFERENCES

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Date of documentation: Aug. 21, 2017

Last update: Jan. 3, 2018

Resource persons
Leakana Oun (N/A) - land user
Horn Sovann (horn.sovann@yahoo.com) - Chief Office of Agricultural Extension at Provincial Department of Agriculture, Forestry and Fisheries, Pursat
Vann Sokhon (vann.sokhon2017@gmail.com) - Chief of District Office of Agriculture, Forestry and Fisheries, Bakan
Kompheak Seng (N/A) - Agronomic Official at District Office of Agriculture, Forestry and Fisheries, Kandieng
Khonnary Moeun (N/A) - Commune Extension Worker at Svay Luong Commune.

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_3142/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

Links to relevant information which is available online
- FAO. (2017). Rooftop water collection , drip irrigation and plastic mulching in home garden conditions in drought prone areas of Cambodia. Retrieved November 10, 2017, from : file:///C:/Users/HTPP ROYAL INV/Downloads/TECA - Rooftop water collection, drip irrigation and plastic mulching in home garden conditions in drought prone areas of Cambodia - 2017-05-31.pdf

Automatic pumping equipment (Tim Sophea)

Automatic Pumping System (Ram Pump) Using Natural Stream Flow for Domestic and Agricultural Purposes (Cambodia)

Water pumping engine run by water flow (Ram Pump)

DESCRIPTION

This equipment is able to automatically pump water without the use of fuel, requires little maintenance and can transfer water for domestic and agricultural uses including livestock raising and the cultivation of crops.

A ram pump which uses a natural stream flow is an equipment that pumps water, which is used for long time ago in Europe and some parts of Asia. However, it has been lost, but then because of the requirement, which its processing depends only on water flow and it will work as long as the water flow is available and no need much care that cause this technology is reintroduced (ACF, 2009). As such, this pumping equipment does not need a machine or fossil fuel and requires less labor. According to the above advantages, Mr. Hour Pros, a farmer in Saob Krom village, Saob commune, Preaek Prasab district, Kratie province, is the first person who did the installation. Even though, the cost of installation is relatively high at USD 1,500 depending on the types of materials from which it is manufactured (he selected the high quality of the iron pipe connections), this pumping equipment is quite durable and can be used for up to 20-30 years, he said. Furthermore, it has no adverse impacts on the environment since there are no greenhouse gas emissions.

This ram pump was installed at Sre Ngeat dam, where there is a natural stream flowing throughout the whole year. As a part of the installation of the ram pump the farmer constructed a concrete dam across the stream with a water gate that can be opened. Additionally, a concrete base had to be built 1.5 meters lower than the water level in the dam in order to house the ram pump equipment. A 12-meter steel pipe which is 144 mm in diameter runs straight from the dam's water gate directly to the pumping equipment. From the pumping equipment, there is a 30 mm hose (the size of this outlet must be smaller than that of the inlet) that transfers the pumped water to the location where it is needed. This pump is operated by the air pressure that is created by the water flowing from the dam to the pipe of pump and uses the air pressure to pushes water through the small pipe to bring water to the place where it is utilized, which is around 600 meters away at an elevation of around 8 meters compared to the pumping equipment. This ram pump has a pumping capacity of around 1.5 cubic meters per hour and can operate for 24-hours a day, with the ability to pump up to a height of 20 meters.

The water that is supplied by the ram pump is stored in two big water tanks (each one with a capacity of 4.7 m3), which can then be used for household consumption, the raising of about 100 chickens, and for the open valve irrigation of 5 ha of agricultural land. Another advantage of this pump system is that it does not affect the water quantity or pollute the downstream flow due to the fact that this system only took about 20-30 % of the water from the dam; 70-80% of the water was able to flow downstream, and so this allocation of the water supply did not cause any dispute between upstream and downstream users.

LOCATION

Location: Saob Krom Village, Saob commune, Preaek Prasab district, Kratie province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 105.95203, 12.43186

Spread of the Technology: applied at specific points/ concentrated on a small area

Date of implementation: 2015

Type of introduction

☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☑ during experiments/ research
☐ through projects/ external interventions
☑ Research on the Internet


Structure of the pumping equipment (Tim Sophea)


The crops irrigated by the ramp pump (Tim Sophea)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☑ reduce risk of disasters
☑ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use

Waterways, waterbodies, wetlands - Ponds, dams
Main products/ services: Sre Ngeat dam can provide water all year round both in dry and rainy seasons.

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 1
Land use before implementation of the Technology: n.a.
Livestock density: n.a.

Purpose related to land degradation

☐ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

water degradation - Ha: aridification

SLM group

- irrigation management (incl. water supply, drainage)
- water diversion and drainage

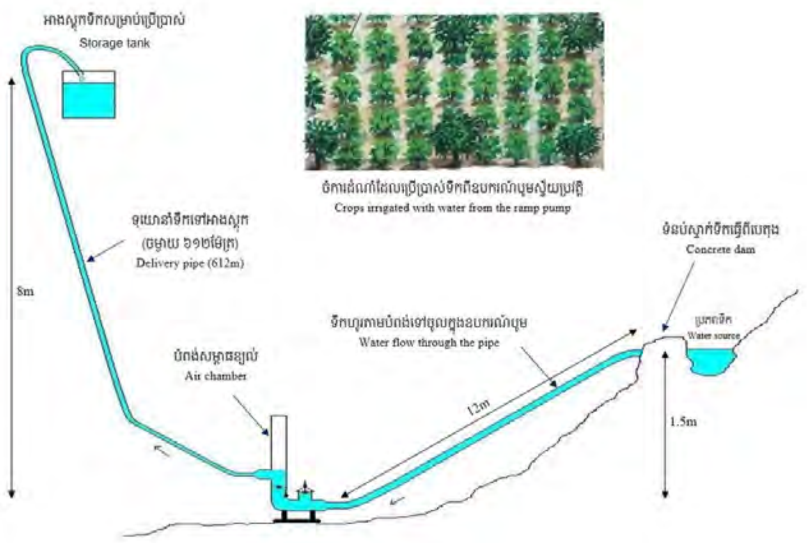
SLM measures

structural measures - S7: Water harvesting/ supply/ irrigation equipment

TECHNICAL DRAWING

Technical specifications

This pumping system is located on a natural stream flow of 1.5 meters height in comparison with the ground of placing the equipment. A 12 meter steel pipe which is 144 mm in diameter runs straight from the dam's water gate directly to the pumping equipment. The outlet hose is 30 mm in diameter. The distance from the pump to the area where the water is being used is around 600 meters, and it lies at an elevation of 8 meters compared to the pumping point. The water is pumped up at 1.5 cubic meters per hour and can be pushed up to a height of 20 meters.



Author: Ms. Om Sovanny and Ms. Be Gechkim

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology unit (unit: **Automatic Pumping Device** volume, length: **Setup space: 1 square meter**)
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 20000 Riel

Most important factors affecting the costs

Construction materials and hose that is needed because of far distance between the ram pump and water use places.

Establishment activities

1. Buy materials (Timing/ frequency: Dry season)
2. Equipment preparation (Timing/ frequency: Dry season)
3. Equipment installation (Timing/ frequency: Dry season)
4. Preparation of irrigation system for vegetable (Timing/ frequency: Dry season)

Establishment inputs and costs (per Automatic Pumping Device)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Total of establishment that done by themselves and materials	Total	1.0	6000000.0	6000000.0	100.0
Total costs for establishment of the Technology				**6000000.0**	

Maintenance activities

1. Access water for using everyday (Timing/ frequency: Everyday)
2. Change valve (Timing/ frequency: Every each years)

Maintenance inputs and costs (per Automatic Pumping Device)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Change valve	set	1.0	100000.0	100000.0	100.0
Total costs for maintenance of the Technology				**100000.0**	

NATURAL ENVIRONMENT

Average annual rainfall

- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone

- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate

Average annual rainfall in mm: 1138.2
The average annual rainfall in 2015 is 1138.2 mm, in 2014 is 1696.5 mm, in 2013 is 1661.8 mm.
Name of the meteorological station: Department of Meteorology, Ministry of Water Resources and Meteorology (2015)

Slope

Landforms

Altitude

Technology is applied in

☐ flat (0-2%)
☐ gentle (3-5%)
☐ moderate (6-10%)
☐ rolling (11-15%)
☑ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

☐ plateau/plains
☐ ridges
☐ mountain slopes
☑ hill slopes
☐ footslopes
☐ valley floors

☑ 0-100 m a.s.l.
☐ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
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☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

☐ convex situations
☑ concave situations
☐ not relevant

Soil depth
☐ very shallow (0-20 cm)
☐ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☑ very deep (> 120 cm)

Soil texture (topsoil)
☑ coarse/ light (sandy)
☐ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☑ high (>3%)
☐ medium (1-3%)
☐ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☑ good
☐ medium
☐ poor/ none

Water quality (untreated)
☐ good drinking water
☐ poor drinking water (treatment required)
☑ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☐ high
☐ medium
☑ low

Habitat diversity
☐ high
☐ medium
☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☐ mixed (subsistence/ commercial
☑ commercial/ market

Off-farm income
☐ less than 10% of all income
☑ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
☐ poor
☑ average
☐ rich
☐ very rich

Level of mechanization
☐ manual work
☐ animal traction
☑ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☐ women
☑ men

Age
☐ children
☐ youth
☑ middle-aged
☐ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☑ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☐ small-scale
☑ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☑ communal/ village
☐ group
☐ individual, not titled
☐ individual, titled

Land use rights
☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual

Water use rights
☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor	☐	☑	☐	good
education	poor	☐	☑	☐	good
technical assistance	poor	☐	☐	☑	good
employment (e.g. off-farm)	poor	☐	☐	☑	good
markets	poor	☐	☑	☐	good
energy	poor	☑	☐	☐	good
roads and transport	poor	☑	☐	☐	good
drinking water and sanitation	poor	☐	☐	☑	good
financial services	poor	☐	☐	☑	good

IMPACTS

Socio-economic impacts

Crop production
decreased ☐ ☐ ☐ ☐ ☐ ☑ ☐ increased

Crop production increased because there is enough water for irrigation leading to increased crop production.

risk of production failure
increased ☐ ☐ ☐ ☐ ☐ ☑ ☐ decreased

Can be managed because of enough water from the river is easily available now and it does not require a lot of labor.

water availability for livestock	decreased	☐☐☐☐☐✓☐	increased	Ram pump can provide enough water all the time with less labor.
irrigation water availability	decreased	☐☐☐☐☐✓☐	increased	More water can be extracted automatically.
expenses on agricultural inputs	increased	☐☐☐☐☐☐✓	decreased	The using of equipment is help to reduce labor, time, cost of reparation, and no needs much maintenance. This technology also reduced fuel consumption for pumping water because ram pump is powered by the water flow.
farm income	decreased	☐☐☐☐☐☐✓	increased	Increase in revenue because it does not cost much to pump water. In addition more crops can be grown now.
diversity of income sources	decreased	☐☐☐☐☐☐✓	increased	Because enough water for irrigate is available now more different crops are grown now.
economic disparities	increased	☐☐☐☐☐✓☐	decreased	With this technology extra income can be generated and furthermore the costs of irrigation were reduced.
workload	increased	☐☐☐☐☐✓☐	decreased	The workload decreased due to the automatically working ram pump.

Socio-cultural impacts

SLM/ land degradation knowledge	reduced	☐☐☐☐☐✓☐	improved	Regarding the water pump technology the farmer improved his knowledge constantly by doing. And actually he got enough experience to act as facilitator for other farmers. This means he shares his knowledge with neighbors which drives them to use this technology too.

Ecological impacts

water quantity	decreased	☐☐☐✓☐☐☐	increased	The quantity of water is not reduced or increased as the ram pump accesses only 20 to 30% of water flow and it does not cuts off water flow.
excess water drainage	reduced	☐☐☐☐☐☐✓	improved	Ram pump can be used to extract water regularly without labor.

Off-site impacts

water availability (groundwater, springs)	decreased	☐☐☐✓☐☐☐	increased	Other farmers and neighbors still get water from the dam because the system has accessed to water only 20 to 30%.
impact of greenhouse gases	increased	☐☐☐☐☐✓☐	reduced	Without using any machines that it does not emit greenhouse gases.

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐☐✓☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

The farmer gets many benefits because before had to expense a lot for the labour to pump the water from well and also he had to spend money for fuel which is not anymore necessary now.

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes		
Gradual climate change			
annual temperature increase	not well at all	☐☐☐✓☐	very well
annual rainfall decrease	not well at all	☐☐☐✓☐	very well
Climate-related extremes (disasters)			
drought	not well at all	☐☐☐✓☐	very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology
☐ single cases/ experimental
☑ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?
☐ 0-10%
☐ 10-50%
☐ 50-90%
☑ 90-100%

Has the Technology been modified recently to adapt to changing conditions?
☐ Yes
☑ No

To which changing conditions?
☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view
- Even it costs much at the beginning it still gain a better profit compared to the use of pumping by machine with gasoline for regular water access.
- Does not involve the use of too much labor because it is able to pump water by itself.
- Water for irrigation is available at all times and during all seasons.
- An increase in income through the improved crop cultivation deploying the water supplied by the ram pump.

Strengths: compiler's or other key resource person's view
- A reduction of impacts on the environment because no fuel is being used in the pumping process.
- A ram pump can operate for many years and does not cost a lot to maintain.
- A reduction in the amount of labor and time to obtain water for consumption.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome
- The equipment is expensive to install. → Save money in order to purchase one.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome
- -

REFERENCES

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Date of documentation: May 2, 2017

Last update: March 2, 2018

Resource persons
vann vun (vannvun278@gmail.com) - Acting Chief of District Office of Agriculture, Forestry and Fisheries ,Preaek Prasab
Pros Hour (Facebook: Kraties' chicken farm (In Khmer)) - land user
Song Sopheak (N/A) - Commune Extension Worker at Saob commune office
Sivin Sak (saksivin@gmail.com) - Chief of District Office of Agriculture, Forestry and Fisheries, Sambo

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_2136/

Linked SLM data
n.a.

Documentation was faciliated by
Institution
- Royal University of Agriculture (RUA) - Cambodia

Project
- Scaling-up SLM practices by smallholder farmers (IFAD)

Key references
- ACF (2009). Hydraulic Ram Pump Systems. From: https://www.pseau.org/outils/ouvrages/acf_gravity_fed_system_in_rural_areas_6_hydraulic_ram_pump_systems_2009.pdf

Links to relevant information which is available online
- Judy of the Woods. Homemade Hydraulic Ram Pump. Retrieved on May 20 2017 from: http://www.judyofthewoods.net/diy/ram_pump.html
- Hydraulic ram pump 8 inches in Cambodia. Retrieved on May 20 2017 from: https://www.youtube.com/watch?v=5MiLas_FCfQ


Solar water pump (Ms. Lay Nary)

Use of solar water pumping to adapt to climate change (Cambodia)

Solar water pumping system

DESCRIPTION

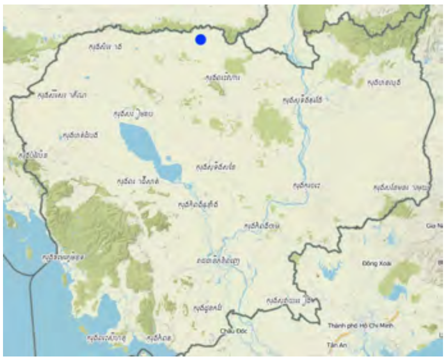
A solar water pump is a technology that uses solar panels to convert the solar power to electricity for pumping water from different sources including an underground source of water. The use of solar water pump is to reduces the operating costs, and avoid the CO2 emission, which is a good option for increasing climate resilience, and contributing to climate change mitigation.

The solar water pump is an innovation that uses solar panels to convert the solar power to electricity for pumping water. It is an optimum choice to help reduce the impacts of climate change. The farmers in Thomacheat Samdach Te Chhor Hun Sen, Sror Aem Commune, Choam Ksant District, Preah Vihear Province, Cambodia previously used the water from ponds for the irrigation of their fields. But this supply was insufficient. In order to resolve the issue, the Cambodia Center for Study and Development in Agriculture (CEDAC) implemented a project and provided a bore hole with a solar powered pump in the commune in 2011 so as to irrigate the crops. In 2014, the Provincial Department of Agriculture, Forestry and Fishery (PDAFF under the support of the National Adaptation Programme of Action (NAPA Follow up phase 2) gave a set of solar water pump which was implemented in the commune for irrigating also the vegetable fields. They offered the village seven solar water pumps in total. One solar water pump has been installed at the house of Mr. Mao Sarath. The solar panels are portable, as sometime the solar power is variable.

The solar pump system consists of solar panels mounted on the top of a wooden structure, a pump motor, a pump inverter, a water storage tank with a supporting structure and electric cables. For its installation, a bore hole firstly needs to be drilled, and a pump needs to be put in place to draw the water from the bore hole and a for water delivery a drip pipe set has to be putted on the vegetable field. Then the supporting structures for two water storage tanks need to be installed which one of 4.8 and one of 2.04 meters in height. After the water storage tanks have been connected with a pump motor. Nine solar panels were fastened on the top of the water tank support construction and a pump inverter has been attached to generate electricity. The water in the tank has to be monitored regularly to secure permanent supply of water. The two water storage tanks have a capacity of 5000 liters which is enough for irrigating the crops and for the consumption of 3 households. Due to this kind of water supply facility the resilience to climate change has been increased and in consequence the emigration has been reduced. More people turned back to the agricultural sector, including farming.

The advantages of the technique are that water can be pumped automatically, that it saves labor and time, it does not use fuel, it reduces the CO2 emission, and it can deliver water at a considerable distance. A budget of 2000 USD was left to maintain the solar water pumps before the project has been completed. This budget was managed by the Border Development and Natural Agriculture Community; however, the community could use this budget for example for their members to take out a loan with an interest rate of 2% per month. After one year of the installation of the water pump, Mr. Mao Sarath expected to sell drinking water to other villagers during dry season or drought condition at cost of 1,500 Riel per cubic meter (excluded the 3 mentioned household). But until now, he was not able to do so due to the fact that other villagers were able to

LOCATION



Location: Rural area, Thomacheat Samdach Te Chhor Hun Sen, Sror Aem commune, Choam Ksant district, Preah Vihear province, Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 104.70201, 14.26294

Spread of the Technology: applied at specific points/ concentrated on a small area

Date of implementation: 2012

Type of introduction

☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☑ through projects/ external interventions

get access to bore holes with pumps and ponds by support of other NGOs too.

In short, the solar water pump is an innovation which uses solar energy to power a motor, thereby replacing a fuel powered motor which would have heavy impacts on the environment. The water is used to irrigate crops in the fields as well as for household consumption by the inhabitants of the village. This is to replace the bore holes with pumps in all of the different households, as villagers are now able to just drill one and install a solar powered pump with water storage tanks, and drip irrigation which provides water more easily to each household in the village.

Solar powered water pump installation (Mr. Tim Sophea)

Irrigated crops benefitting from the solar water pump. (Mr. Tim Sophea)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☐ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☑ reduce risk of disasters
☑ adapt to climate change/ extremes and its impacts
☑ mitigate climate change and its impacts
☐ create beneficial economic impact
☐ create beneficial social impact

Land use

Cropland - Perennial (non-woody) cropping
other (specify): short-term cropping
Main crops (cash and food crops): The farmer grew short-term crops such as mango, jack-fruit, eggplant, and luffa gourds.

Water supply

☐ rainfed
☐ mixed rainfed-irrigated
☑ full irrigation

Number of growing seasons per year: 3

Land use before implementation of the Technology: Pond and pumping well

Livestock density: n.a.

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

water degradation - Ha: aridification

SLM group

- water harvesting
- irrigation management (incl. water supply, drainage)
- water diversion and drainage

SLM measures

structural measures - S7: Water harvesting/ supply/ irrigation equipment, S10: Energy saving measures

TECHNICAL DRAWING

Technical specifications

The solar pump system consists of solar panels mounted on the top of a wooden structure, a pump motor, a pump inverter, and a water storage tanks with a supporting structure and electric cables. The bore hole has a depth of 29 meters and a diameter of 0.08 m . One water tank holding construction hasa height of 2.04 meters and the other has a height of 2.8 meter. The water tanks have a volume of 5000 liters. The solar water pump is able to draw 6-7 cubic meters per day and if there is full sun shine it can reach up to 8 cubic meters per day.

Author: Mr. Khuon Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology unit (unit: **1 solar pump to keep two water tanks of 5000 litters filled up** volume, length: **Tank volume is 5000 litter per tank**)
- Currency used for cost calculation: **Riel**
- Exchange rate (to USD): 1 USD = 4000.0 Riel
- Average wage cost of hired labour per day: 20000 Riel

Most important factors affecting the costs

The price of solar water pumping is expensive so that it affects the farmer's expenditure seriously.

Establishment activities

1. Constructiong of pumping well (Timing/ frequency: February)
2. water tank support (Timing/ frequency: May)
3. Buying water tanks (Timing/ frequency: May)
4. Solar water pumping intallation (Timing/ frequency: May)
5. Pump monitor (Timing/ frequency: May)

Establishment inputs and costs (per 1 solar pump to keep two water tanks of 5000 litters filled up)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Construction of pumping well	set	1.0	1600000.0	1600000.0	
Building a wooden structure	set	1.0	800000.0	800000.0	
Equipment					
Water tanks	piece	2.0	2000000.0	4000000.0	
Controller unit	set	1.0	4000000.0	4000000.0	
Pump motor including the solar panels	set	1.0	8000000.0	8000000.0	
Construction material					
water tank supports	Number	2.0	800000.0	1600000.0	100.0
Total costs for establishment of the Technology				**20000000.0**	

Maintenance activities

1. Checking the water levels and control of the installation (Timing/ frequency: Dry season)

Maintenance inputs and costs (per 1 solar pump to keep two water tanks of 5000 litters filled up)

Specify input	Unit	Quantity	Costs per Unit (Riel)	Total costs per input (Riel)	% of costs borne by land users
Labour					
Repair work on the pump motor	number	1.0	400000.0	400000.0	100.0
Total costs for maintenance of the Technology				**400000.0**	

NATURAL ENVIRONMENT

Average annual rainfall

- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☐ 1,001-1,500 mm

Agro-climatic zone

- ☐ humid
- ☐ sub-humid
- ☑ semi-arid
- ☐ arid

Specifications on climate

In 2015, the annual rainfall was 1429.3 mm
In 2014, the annual rainfall was 1647.3 mm

Name of the meteorological station: Ministry of Water Resource and Meteorology, 2015

☑ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Monsoon with two main seasons - a dry and a rainy season.

Slope
☐ flat (0-2%)
☑ gentle (3-5%)
☐ moderate (6-10%)
☐ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☐ 0-100 m a.s.l.
☐ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☐ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☑ very deep (> 120 cm)

Soil texture (topsoil)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☑ high (>3%)
☐ medium (1-3%)
☐ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☐ good
☑ medium
☐ poor/ none

Water quality (untreated)
☐ good drinking water
☐ poor drinking water (treatment required)
☑ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☐ high
☐ medium
☑ low

Habitat diversity
☐ high
☐ medium
☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☑ mixed (subsistence/ commercial
☐ commercial/ market

Off-farm income
☑ less than 10% of all income
☐ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
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☑ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☐ animal traction
☑ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☐ women
☑ men

Age
☐ children
☐ youth
☐ middle-aged
☑ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☑ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
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☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☑ small-scale
☐ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☑ leased
☑ individual

Water use rights
☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor			✓	good
education	poor			✓	good
technical assistance	poor			✓	good
employment (e.g. off-farm)	poor			✓	good
markets	poor		✓		good
energy	poor	✓			good
roads and transport	poor			✓	good
drinking water and sanitation	poor			✓	good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased						✓		increased	Quantity before SLM: 30% Quantity after SLM: 60%
drinking water availability	decreased					✓			increased	The farmer was able to have better access to water for crop irrigation and animal raising.
drinking water quality	decreased					✓			increased	The drinking water quality is sligthly increased, but the farmer is also able to boil the water before drinking.
irrigation water availability	decreased							✓	increased	After the solar powered water pump installation, the farmer hase access to water forcrop irrigation during all seasonal growings.
irrigation water quality	decreased						✓		increased	The irrigation water quality is enough good even if it is limy. It does not impact the plant growing.
demand for irrigation water	increased	✓							decreased	Quantity before SLM: 30% Quantity after SLM: 60%
expenses on agricultural inputs	increased							✓	decreased	The farmer did not spend much due to high support of the project .
farm income	decreased						✓		increased	Before the farmer's income was low due to the fact that the vegetable harvest was low. Because of the drip irrigation system combined with the solar water pump, he was able to cultivate more crops and he gets higher yield.
workload	increased							✓	decreased	Beside the growing of vegetable the farmer now has more free time due to the solar powered pump that supports him to irrigate the crops.

Socio-cultural impacts

land use/ water rights	worsened						✓		improved	The farmer hashis own land for growing vegetable and he has free access to the water for irrigation.
SLM/ land degradation knowledge	reduced							✓	improved	The farmer learned that this technology helps reducing the soil erosion due to the use of drip irrigation and also that solar powered pump contributes to environmental protection by not not using fuel for the pumping machine.

Ecological impacts

water quantity	decreased				✓				increased	As the solar water pump need solar energy to generate electricity, the amount of water to be pumped depends upon the available solar power.
emission of carbon and greenhouse gases	increased						✓		decreased	Due to solar panel driven water pump.

Off-site impacts

impact of greenhouse gases	increased							✓	reduced	Due to solar panels driven water pump for household consumption and irrigation.
None	None					✓			None	Water delivery to neighbors whenever there is not enough water during the drought period.

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative							✓	very positive

Benefits compared with maintenance costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative							✓	very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes							
Gradual climate change								
annual temperature decrease	not well at all			✓			very well	
seasonal temperature increase	not well at all			✓			very well	Season: wet/ rainy season
annual rainfall decrease	not well at all				✓		very well	

seasonal rainfall decrease — not well at all ☐ ☐ ☐ ☑ ☐ very well — Season: wet/ rainy season

Other climate-related consequences

extended growing period — not well at all ☐ ☐ ☐ ☑ ☐ very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☑ 0-10%
☐ 10-50%
☐ 50-90%
☐ 90-100%

Number of households and/ or area covered

7 housholds of Thomacheat Samdach Te Chhor Hun Sen village implemented the technology (the one examined here included)

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Water can be accessed to irrigate crops without the use of a fuel powered pump.
- Economically beneficial as there is no need to buy diesel to pump water.

Strengths: compiler's or other key resource person's view

- Adapting to the impacts of climate change.
- Reducing GHG emissions into the atmosphere.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome

- High expenditure. → Secure assistance from NGOs and other ways to jointly implement this technology.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

- -

REFERENCES

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Date of documentation: Oct. 12, 2017

Last update: March 2, 2018

Resource persons

Sarath Mao - land user
Phearak Thun - Commune extension worker
Chhlath Prach - Official of District Office of Agriculture, Forestry and Fisheries of Choam Khsant
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Full description in the WOCAT database

https://qcat.wocat.net/en/wocat/technologies/view/technologies_3214/

Linked SLM data

n.a.

Documentation was faciliated by

Institution

- Royal University of Agriculture (RUA) - Cambodia

Project

- Scaling-up SLM practices by smallholder farmers (IFAD)

Key references

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Growing corn use drip irrigation (Mr. Kim Soben)

Growing corn using drip irrigation system (Cambodia)

Growing corn using drip irrigation

DESCRIPTION

The cultivation of corn with the use of a drip irrigation system is an efficient technique that saves water and is suitable for irrigation in areas where there is a scarce water supply. Farmers using the drip irrigation system with their corn crops is an adaptation to climate change, in periods such as during the drought period. It's reduces unnecessary evaporation, saves labor and time, improves crop growth and makes it possible to produce a high yield because of a sufficient water supply.

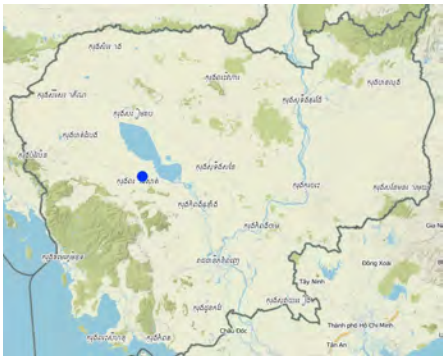
The use of a drip irrigation system is an efficient method that saves water by letting it seep through the drainage network directly into the corn clumps at regular intervals (the seepage rate is 6 liters/hour and the pressure of the water flow is between 1.2 to 2 bar). Moreover, the drip system helps to maintain moisture around the roots of a crop and does not distribute water to superfluous areas at a distance from the crop (John, 2018). In doing so it reduces the weed proficiency and also insures that enough water is provided for the crop especially during the flowering phase. This is essential because a lack of water during this phase can have a significant impact on crop yields. At the same time the use of this drip system enables farmers to adapt to climate change through the efficient use of water especially in areas that experience the adverse impacts of climate change like droughts. Furthermore, a liquid fertilizer can also be directly fed into the drip irrigation system.

In order to cultivate corn one should first scatter cow manure on the ground and then plow the soil three times after which it should be left to dry for seven days. After that it should be plowed again and then the soil is prepared for the ridging of the rows. Once the ridges have been created the drip irrigation system should be installed. This technology was applied on a plot of land with an area of 2301.5 square meters.

In order to nurse the seedlings, the farmer should mix the soil from a termite mound (or other fertile soil) with other materials. The ratio should be 1 portion of fertile soil, with 2 portions of rice husk embers and 2 portions of animal manure. Then this mixture is put into trays and then one corn seed is embedded into each cell. After the seedlings are one week old they should be transplanted. The farmer should use a bamboo stick to dig holes to a depth of 3 cm and then firstly apply D A P (18-46-0) fertilizer after which the seedlings are placed in the holes. Nursery seedlings are healthy and well-balanced as they grow, do not die easily, and produce a higher yield than seeds that are directly planted into the ground. These always have to be replanted as some seeds do not grow, and they tend to not germinate as well as the nursery seedlings. Farmers should plant two lines of seedlings in each row with a gap of 55cm between the lines. Along each of the lines there should be a gap of 30cm between one plant and the next. Farmers are able to grow corn twice a year, once from July to September and the other from February to April.

During the rainy season farmers only need to use the irrigation system for about 10 to 15 minutes in the morning or evening once the land is dry, such as when there has been no rainfall for many days or also on occasions of inadequate rainfall. In the dry season farmers water the corn twice a day for about 30 minutes each time, once in the morning and once in the evening. During the dry season 6 to 7 litters of water are used to irrigate the corn, thereby the water flow rate being 6 liters per hour. Depending on the variation

LOCATION



Location: The farm is near the village., Kampong Krasang Kraom village, Kandieng commune, Kandieng district, Pursat province., Cambodia

No. of Technology sites analysed: single site

Geo-reference of selected sites

- 103.97868, 12.59825

Spread of the Technology: applied at specific points/ concentrated on a small area

Date of implementation: 2014

Type of introduction

☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☑ through projects/ external interventions

in water pressure the flow rate of this drip irrigation system can range between 1 to 4 gallons per hour (1 gallon = 3,785 liters).

The farmers were supported financially by the HARVEST project in 2014 to cover the costs of the drip irrigation system and so their only expenses included the preparation of the seeds, other agricultural inputs and maintenance costs. Regarding the water use for the dry season crop on this area of land, only 600-700 cubic meters of water were consumed, which the farmer sourced from a pond and a small river.

The use of the drip irrigation system helps to reduce the amount of labor necessary for the irrigation of the corn, saves time, is able to maintain unimpaired crop growth when there is not enough water, saves water, and also reduces the growth of weeds between the plants. Therefore, this system facilitates the efficient use of water, helps to adapt to conditions brought on by climate change such as droughts, and is especially beneficial in areas where there is a scarce supply of water.


The corn after one week of growing (Mr. Kim Soben)


The mainline of drip irrigation system (Mr. Kim Soben)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☐ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☑ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact
☑ Reduce water consumption and reduce labor.

Land use

Cropland - Annual cropping
Main crops (cash and food crops): Corn

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Number of growing seasons per year: 3
Land use before implementation of the Technology: Before it was a rice field and over three years, she changed for other crops.
Livestock density: Raise 5 cows

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

physical soil deterioration - Pc: compaction, Pu: loss of bio-productive function due to other activities

biological degradation - Bc: reduction of vegetation cover

water degradation - Ha: aridification

SLM group

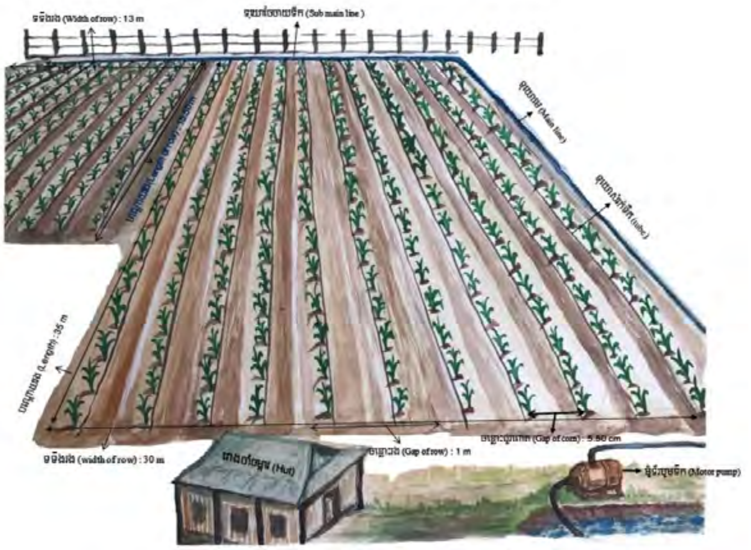
- rotational systems (crop rotation, fallows, shifting cultivation)
- integrated soil fertility management
- irrigation management (incl. water supply, drainage)

SLM measures

agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility

TECHNICAL DRAWING

Technical specifications
The components of the drip irrigation system includes a motor pump, a valve, a filter, a pressure gauge, a main line (with a diameter 60 mm), a sub main line (with a diameter 49 mm), and a tube (diameter 16 mm). The drip irrigation system was applied on a plot of 2301.5 square meters.
Depending on the season there are two ways to prepare the ridges of the rows. Firstly, in the rainy season the farmer should plow the ridges to a height of 50 cm and a width of 1 meter. The gap between each of the rows should be 1 meter and the length of each row is the actual length of the land. In the dry season the ridges of the rows should be plowed to the same length and width but the height should only be 20 cm because in the dry season there is not a lot of rain. Each row gets one drip line.



Author: Mr. Khoun Sophal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **2301.5 square meters**)
- Currency used for cost calculation: **KHR**
- Exchange rate (to USD): 1 USD = 4000.0 KHR
- Average wage cost of hired labour per day: 20000 KHR

Most important factors affecting the costs
The seed and the tube are expensive.

Establishment activities

1. Ploughing the soil (Timing/ frequency: May)
2. Making rows + nursing of corn seedlings+ installing drip irrigation system (Timing/ frequency: May)
3. Making pits + putting fertilizer in pits + planting corn seedling (Timing/ frequency: May)

Establishment inputs and costs (per 2301.5 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
Plow the soil	Person-day	4.7	20000.0	94000.0	100.0
Make row and prepare drip irrigation	Person-day	2.5	20000.0	50000.0	100.0
Nursing and planting the corn seedlings	Person-day	4.0	20000.0	80000.0	100.0
Equipment					
Pump motor	Set	1.0	240000.0	240000.0	100.0
Hoe	Piece	1.0	200000.0	200000.0	30.0
Seed tray	Piece	80.0	2500.0	200000.0	100.0
Plant material					
Corn seed	Pack	3.0	28000.0	84000.0	100.0
Fertilizers and biocides					
Fertilizer (D A P, Kaly, Urea)	Kilogram	7.0	2000.0	14000.0	100.0
Construction material					
Pipe	Meter	100.0	1600.0	160000.0	100.0
Tube	Piece	1.0	200000.0	200000.0	30.0
Total costs for establishment of the Technology				**1322000.0**	

Maintenance activities

1. Irrigated corn by using drip irrigation system when there is no rain. (Timing/ frequency: drought or dry season)
2. Applying fertilizer 4 times per crop cycle. (Timing/ frequency: during maintenance)
3. Create the ridge of the row after growth of 15 or 18 days (Timing/ frequency: during maintenance)
4. Cutting leaf of corn two times: corn have 20 days and one month (Timing/ frequency: during maintenance)

Maintenance inputs and costs (per 2301.5 square meters)

Specify input	Unit	Quantity	Costs per Unit (KHR)	Total costs per input (KHR)	% of costs borne by land users
Labour					
Create the ridge of the rows	Person-day	1.0	20000.0	20000.0	100.0
Cutting the leafs of the corn	person-day	1.0	20000.0	20000.0	100.0
Fertilizers and biocides					
Fertilizer	Kilogram	40.0	2000.0	80000.0	100.0
Other					
Electricity for water pumping	kilowatt-hour	267.0	790.0	210930.0	100.0
Total costs for maintenance of the Technology				330930.0	

NATURAL ENVIRONMENT

Average annual rainfall
☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☐ 1,001-1,500 mm
☑ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone
☐ humid
☑ sub-humid
☐ semi-arid
☐ arid

Specifications on climate
Average annual rainfall in mm: 1225.7
Annual rainfall in 2015 is 1225.7 mm and in 2014 is 1128.1 mm and in 2013 is 1316 mm.
Name of the meteorological station: Ministry of Water Resources and Meteorology (2015)
The weather is warm and humid and there are 2 seasons: dry season and rainy season.

Slope
☑ flat (0-2%)
☐ gentle (3-5%)
☐ moderate (6-10%)
☐ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☑ 0-100 m a.s.l.
☐ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☐ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☑ very deep (> 120 cm)

Soil texture (topsoil)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☑ medium (1-3%)
☐ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☑ good
☐ medium
☐ poor/ none

Water quality (untreated)
☑ good drinking water
☐ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☑ Yes
☐ No

Species diversity
☐ high
☐ medium
☑ low

Habitat diversity
☐ high
☐ medium
☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☐ mixed (subsistence/ commercial
☑ commercial/ market

Off-farm income
☐ less than 10% of all income
☑ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
☐ poor
☑ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☐ animal traction
☑ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☑ women
☐ men

Age
☐ children
☐ youth
☑ middle-aged
☐ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☑ 2-5 ha

Scale
☐ small-scale
☑ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

☐ individual, not titled
☑ individual, titled

Water use rights
☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor			✓	good
education	poor			✓	good
technical assistance	poor	✓			good
employment (e.g. off-farm)	poor		✓		good
markets	poor			✓	good
energy	poor	✓			good
roads and transport	poor			✓	good
drinking water and sanitation	poor			✓	good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased						✓		increased	Quantity before SLM: 30% Quantity after SLM: 80% By applying drip irrigation system, she can grow crops two or three times per year.
crop quality	decreased						✓		increased	Using cow manure and have enough water to use.
risk of production failure	increased						✓		decreased	Nursing before planting is making seedling grow well and do not die when planting.
land management	hindered						✓		simplified	Crop can protect soil erosion and soil have more nutrient than before because using cow manure and soil cover by crop also keep soil moisture well.
expenses on agricultural inputs	increased					✓			decreased	Reduce spending on use chemical fertilizer and labor cost.
farm income	decreased						✓		increased	Because the growing corn can grow two or three time per year and get high yield.
workload	increased						✓		decreased	Do not need much labor for irrigation and maintenance of the corn.

Socio-cultural impacts

food security/ self-sufficiency	reduced						✓		improved	Can grow two or three times per year and get high yield.
health situation	worsened						✓		improved	Do not effect health because don't use much chemical fertilizer.
SLM/ land degradation knowledge	reduced						✓		improved	nursery before planting, using drip irrigation can save water for irrigation crop.

Ecological impacts

evaporation	increased						✓		decreased	Crop is cover soil reduce evaporation and keep soil moisture as well.
soil moisture	decreased						✓		increased	Crop keep soil moisture well.
soil compaction	increased						✓		reduced	The using cow manure make soil not compact and the crop keep moisture because soil can get water daily from drip irrigation system.
soil organic matter/ below ground C	decreased						✓		increased	Using cow manure and residue crop help to increase nutrient in soil.

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative					✓			very positive
Long-term returns	very negative						✓		very positive

Benefits compared with maintenance costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative						✓		very positive

CLIMATE CHANGE

Climate change/ extreme to which the Technology is exposed	How the Technology copes with these changes/extremes						
Gradual climate change							
annual temperature increase	not well at all					✓	very well
annual rainfall increase	not well at all			✓			very well
Climate-related extremes (disasters)							
drought	not well at all					✓	very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology
☐ single cases/ experimental
☑ 1-10%
☐ 10-50%
☐ more than 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?
☑ 0-10%
☐ 10-50%
☐ 50-90%
☐ 90-100%

Number of households and/ or area covered
4 households of the village

Has the Technology been modified recently to adapt to changing conditions?
☐ Yes
☑ No

To which changing conditions?
☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view
- Reduces the amount of labor necessary for the crop irrigation.
- Produces a high yield.

Strengths: compiler's or other key resource person's view
- The trays of the seedlings in the corn nursery only require a small amount of soil and the seedlings grow well when they are transferred to the field.
- Saves time and water for irrigation.
- There are less weeds and a greater abundance of micro-organisms in the soil, which produces a high yield.

Weaknesses/ disadvantages/ risks: land user's view → how to overcome
- The amount of time that is spent collecting the drip line after the crop has been harvested. → Expend effort in collecting the drip line.
- It is expensive → Farmers need to know how to maintain and connect the drip line by themselves once it breaks, as well as wash it well and handle it properly.
- The remain drip line cannot be used for anything. → Farmers suggest to burn it or bury it in the soil.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's view → how to overcome

REFERENCES

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Date of documentation: Aug. 22, 2017

Last update: April 23, 2018

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Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_3144/

Linked SLM data
n.a.

Documentation was faciliated by
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