

# Cost-Benefit Analysis of Vetiver System-based Land Rehabilitation Measures: Landslide Damaged Mountainous Agricultural Areas



**Jaruntorn Boonyanuphap**  
**Sumath Adulavidhaya**

***THE FIFTH INTERNATIONAL CONFERENCE ON VETIVER (ICV-5)***

***October 28 to 30, 2011***

***Lucknow, India***

***Naresuan University, Phitsanulok, THAILAND***



# **Presentation outline**

- ❑ Introduction**
- ❑ Impacts of landslide on the mixed-fruit tree orchard on mountainous areas**
- ❑ Research objectives & Scope of the study**
- ❑ Research Methods**
- ❑ Results**
- ❑ Conclusion**

# INTRODUCTION

## *Problem statement*

the May 2006 landslide has damaged large mountain areas of high potential agricultural productivity in Maepoon Subdistrict, Uttaradit Province, Lower Northern Thailand. Landslide-damaged agricultural lands are without proper rehabilitation.







2008 6 12



# Impacts of landslide on the fruit tree orchard on mountainous areas

- Loss in fruit trees



Significant decrease in fruit yields

- Top soil loss & soil erosion

- Decline in soil fertility



Land degradation

- Sedimentations of silt and sand

- Additional landslide & secondary risk

- Deforestation

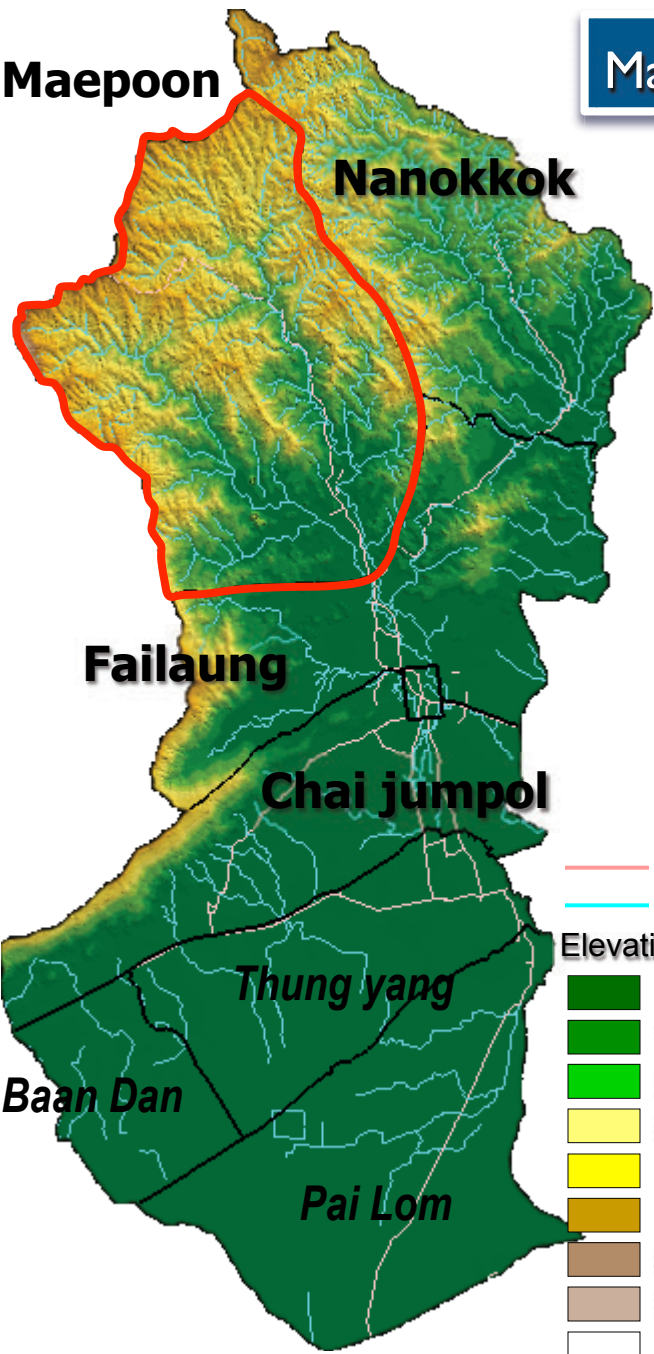


Change in agricultural soil productivity

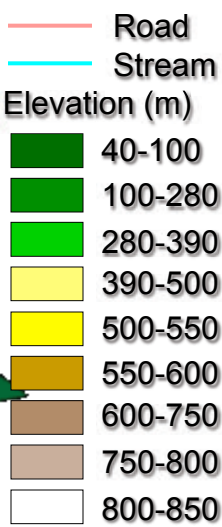


# Maepoon

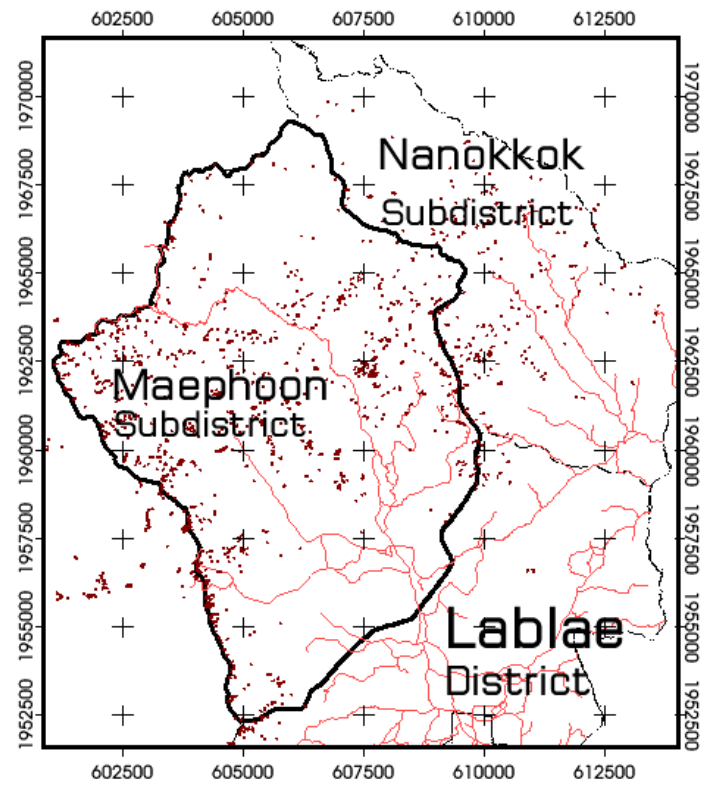
# Mae-Poon Subdistrict



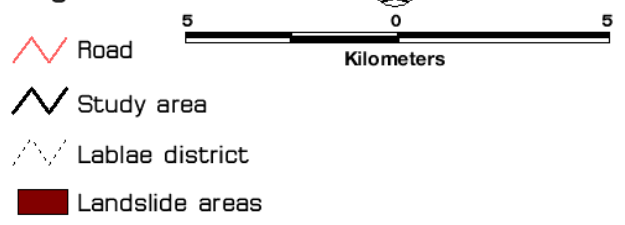
Total area: 1,893.4 ha.  
 Elevation: 49 to 840 m MSL.  
 Slope: 0 to 75 degree  
 Number of Household: 1,252



# The year 2006 landslide location



## Legend



## Research Questions:

1. What are the cost and benefit of landslide rehabilitation measures?
2. How are the distribution of costs and benefits among stakeholders?
3. What are the incentives for upstream farmers and landholders to rehabilitate agricultural land damaged by landslide in the upstream region?

## Research Objectives

- to undertake the cost-benefit analysis (CBA) of landslide rehabilitation measures under options and status quo.
- to determine the best measure for landslide rehabilitation in the mountainous agricultural area
- to understand the incentives for farmers and landholders in the upstream region to address the problems of soil erosion and soil fertility degradation.



## Scope of the Study

- ❑ The research was conducted in **Maepoon Subdistrict** with area of about 1,800 ha., where was the worst hit area of the May 2006 landslide.
- ❑ This study focuses on a cost and benefit analysis of different measures to rehabilitate the agricultural land, in terms of **soil fertility improvement** and **soil erosion control**.

# Research Methods

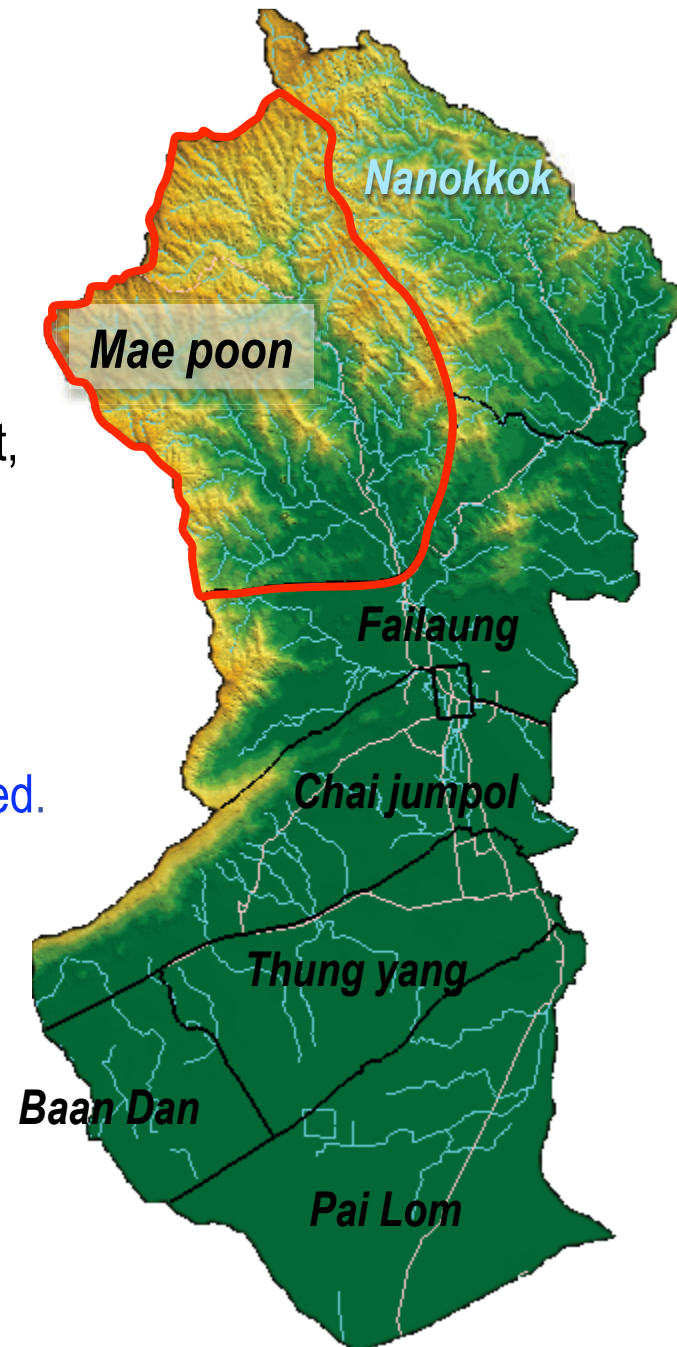
## 1. Defining the stakeholder

### 1.1 On-site stakeholders (Upstream):

- Stakeholders who are residents in Meapoon Subdistrict, land owner who are not residents, local administrative offices, and social groups in Meapoon Subdistrict
- ❖ The upstream is a region of Meapoon Subdistrict, where land rehabilitation measures are considered.

### 1.2 Off-site stakeholders (Downstream):

- The downstream recipients of soil erosion damage and potential landslide damage
- ❖ The downstream is a region outside Meapoon Subdistrict in the same watershed.





# Research Methods

## 2. Designing the measure options of rehabilitating areas hit by landslide

- three measures for land rehabilitation were designed by brainstorming among key stakeholders and researchers
- considering a concept of the vetiver system (VS)
- Project period: 20 years

### Option 1

vetiver grass & waterway constructions



### Option 2

vetiver grass & legume & durian seedling



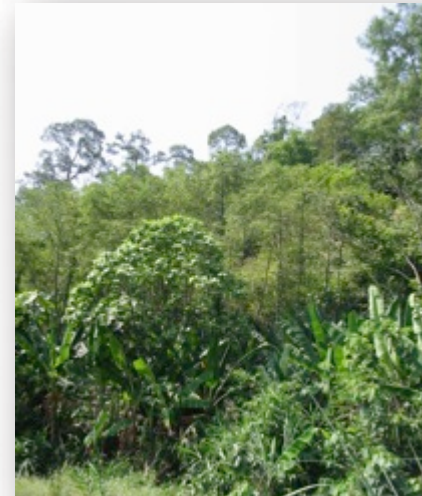
### Option 3

vetiver grass & banana & durian seedling



### Status quo

Native pioneer plant species



## Measure I

# Planting of vetiver grass with waterway constructions

### Planting pattern:

- Planting vetiver grass
- Planting space : 5 cm.
- Planting row space : 4 m.
- Number of vetiver grass : 760 grasses/planting row. Total vetiver grass used : 8,360 grasses
- Size of waterway on both sides of the plot is one meter wide and 50 cm. deep.



40 m.

○ vetiver grass



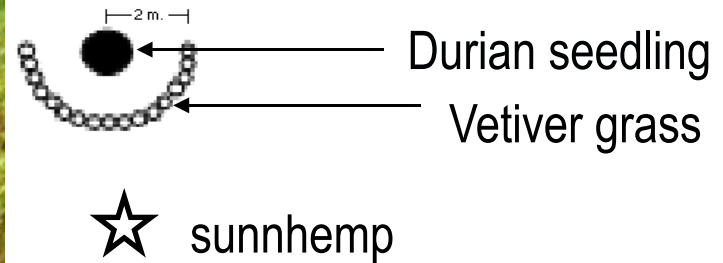


## Measure 2

# Planting of vetiver grass with intercropping of durian seedling and sunnhemp, and constructions of waterway

### Planting pattern:

- Planting vetiver grass with intercropping of durian seedling (3 years old)
- Planting space of fruit seedling is 8x8 m. (25 fruit seedling per rai)
- Planting vetiver grass in half sphere shape with top opened to trap soil sediment and water outside the fruit canopy
- Planting space between vetiver grass and fruit seedling is 2 m.
- Sunnhemp is seeded in which space between seeding and rows of fruit seedling is about 4 m.

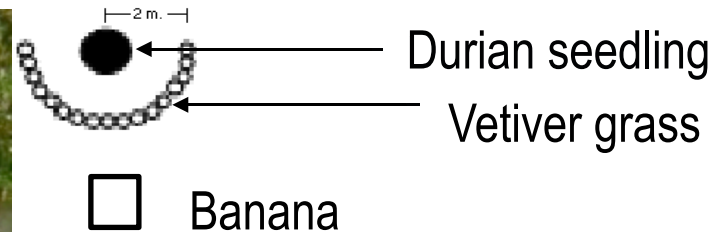




## Measure 3

# Planting of vetiver grass with intercropping of durian seedling and banana, and constructions of waterway

- Planting pattern:**
- Planting vetiver grass with intercropping of durian seedling (3 years old)
  - Planting space of fruit seedling is 8x8 m. (25 fruit seedling per rai)
  - Planting vetiver grass in half sphere shape with top opened to trap soil sediment and water outside the fruit canopy
  - Planting space between vetiver grass and fruit seedling is 2 m.
  - Sunnhemp is seeded in which space between seeding and rows of fruit seedling is about 4 m.







Bamboo grass, wild banana, and *Helicteres lanata* grow on landslide-damaged area

# Research Methods

## 3. Listing of costs and benefits

The criteria for determining the costs and benefits of each option measures were based on group discussions of stakeholders

## 4. Questionnaire design, pretest, and implementation

## 5. Quantifying costs and benefits

- Costs and benefits were quantified in particular unit per Rai (1 Rai = 0.16 hectare)
- Durian can yield 70 kg/tree/year. (1750 kg/Rai/year)
- Benefits of measures for land rehabilitation include increase in major elements (N, P, K) and organic matters contents.



## **Research Methods**

**6. Monetization of the costs and benefits**

**7. Calculation of the NPV**

**8. Sensitivity analysis**

- discount rates of 3%, 8%, 6% (base case) and 10%**
- under conditions of drought, cold wave, and summer storm cause decline in fruit yield at 30% (unusual climate condition)**
- under conditions of increase in prices of materials by 30%**

**9. Policy implication**



# Results

## 1. Listing of costs and benefits

Parameters	Status quo	Option 1	Option 2	Option 3
<b>Costs</b>				
• Cost of weeding and equipment rent (Baht)	✓	✓	✓	✓
• Costs of waterway construction (Baht)	✓	✓	✓	✓
• Cost of vetiver grass (Baht)	✓	✓	✓	✓
• Wage of vetiver grass planting (Baht)	✓	✓	✓	✓
• Operation costs of watering and weeding (Baht)	-	-	✓	✓
• Costs of planting pit preparation for durian seeding (Baht)	-	-	✓	✓
• Costs of basal fertilizer for durian seedling planting (Baht)	-	-	✓	✓
• Wage of basal fertilizer application for seedling planting (Baht)	-	-	✓	✓
• Costs of fertilizer applied throughout the year (Baht)	-	-	✓	✓
• Wage of fertilizer application throughout year (Baht)	-	-	✓	✓
• Costs of durian seedling and planting wage (Baht)	-	-	✓	✓
• Costs of sunnhemp and planting wage (Baht)	-	-	✓	-

# Results

## 1. Listing of costs and benefits and potential impacts

Parameters	Status quo	Option 1	Option 2	Option 3
<b>Costs</b>				
• Costs of maintenance after planting (Baht)	-	-	✓	✓
• Costs of banana corm and planting wage (Baht)	-	-	-	✓
• Wage of banana removal (Baht)	-	-	-	✓
• Cost of removing sediments in drainage and streams (Baht)	✓	-	-	-
• Opportunity cost of durian produces (Kg)	✓	✓	-	-
• Loss of soil fertility (Surface layer; 0-5 cm. depth)				
<input type="checkbox"/> Nitrogen (kg)	✓	✓	✓	✓
<input type="checkbox"/> Phosphorus (kg)	✓	✓	✓	✓
<input type="checkbox"/> Potassium (kg)	✓	✓	✓	✓
<input type="checkbox"/> Organic matter (kg)	✓	✓	✓	✓



# Results

## 1. Listing of costs and benefits and potential impacts

Parameters	Status quo	Option 1	Option 2	Option 3
<b>Benefit</b>				
• <b>Increase in soil fertility (Surface layer; 0-5 cm. depth)</b>				
<input type="checkbox"/> Nitrogen (kg)	✓	✓	✓	✓
<input type="checkbox"/> Phosphorus (kg)	✓	✓	✓	✓
<input type="checkbox"/> Potassium (kg)	✓	✓	✓	✓
<input type="checkbox"/> Organic matter (kg)	✓	✓	✓	✓
• <b>Banana yield (Hands)</b>	-	-	-	✓
• <b>Durian yield (Kg)</b>	-	-	✓	✓

# Results

## 2. Quantifying costs and benefits

List of costs and benefits	Measure options
Planting pit preparation, fertilizers, durian seedling, and wage of fertilizer application	<ul style="list-style-type: none"><li>• <b>Measure 1 &amp; Status quo:</b> from year 8</li><li>• <b>Measure 2 &amp; Measure 3:</b> from year 1</li></ul>
Fertilizer application and maintenance	<ul style="list-style-type: none"><li>• <b>Measure 1 &amp; Status quo:</b> from year 8 to year 20</li><li>• <b>Measure 2 &amp; Measure 3:</b> from year 1 to year 20</li></ul>
Labor costs for removing bananas to prevent sunlight for durian growth.	<ul style="list-style-type: none"><li>• <b>Measure 3:</b> at year 4</li></ul>
Labor costs for harvesting bananas	<ul style="list-style-type: none"><li>• <b>Measure 3:</b> from year 2 to year 4</li></ul>
Operation cost of removing sediments in drainage and streams	<ul style="list-style-type: none"><li>• <b>Status quo:</b> from year 1 to year 7</li></ul>
Loss and increase in soil fertility	<ul style="list-style-type: none"><li>• <b>All measures:</b> from year 1 to year 20</li></ul>
Benefits from banana1/	<ul style="list-style-type: none"><li>• <b>Measure 3:</b> from year 2 to year 4</li></ul>
Benefits from durian	<ul style="list-style-type: none"><li>• <b>Measure 1 &amp; Status quo:</b> from year 13 to year 20</li><li>• <b>Measure 2 &amp; Measure 3:</b> from year 6 to year 20</li></ul>



## Results

### 3. Net present value (NPV) of rehabilitation measures

- NPVs estimated under discounted rate of 6%, and project period of 20 years

(1 USD=30.55 Baht; 1 Rai = 0.16 ha.)

Costs and Benefits	Measure options			
	1	2	3	Status quo
Total Costs (Baht)	63,595	118,501	144,708	65,156
Total Benefits (Baht)	201,837	505,477	515,535	206,243
NPV (Baht / Rai)	138,242	386,976	370,857	141,087

# Results

## 4. Sensitivity analysis

- NPVs estimated for project period of 20 years *(Baht per rai; 1 USD=30.55 Baht; 1 Rai = 0.16 ha.)*

Option	Description	Discount rates				Scenarios		
		3%	6% (Base case)	8%	10%	unusual climate condition	increase in prices of materials	combined conditions
1	vetiver grass with waterway construction	221,518	138,242	101,282	74,262	78,133	123,381	63,272
2	vetiver grass & durian & sunnhemp & waterway	537,986	386,976	314,357	257,561	245,617	355,005	213,646
3	vetiver grass & durian & banana & waterway	512,786	370,857	302,518	249,005	221,479	331,504	182,126
4	Status quo	224,590	141,087	104,043	76,974	80,978	125,610	65,501

## Results

### 5. Cost and benefit distributions among stakeholders

- ❑ Under Status quo, all costs would be equally distributed by the Local Administration Office and landowners in upstream areas.
  - Local Administrative Offices would be responsible for removing sediment in drainage.
  - Since landowners need financial support, based on discussions with the Local Administrative Offices, they indicated that they would be willing to provide partial funding to establish pilot land rehabilitation projects in the landslide-damaged areas.
- ❑ all stakeholders, upstream and downstream, would obtain high benefit from all measures for land rehabilitation excluding Status quo.



## Results

### 5. Cost and benefit distributions among stakeholders

- ❑ Land owners and farmers in upstream region would receive the highest benefit from Measure 3 and Measure 2
  - The farmer can gain income from banana and durian produces.
  - if the land were to be left to naturally regenerate as is the case under Status quo, farmers would benefit from the natural rehabilitation process by native pioneer plants, which can increase the organic matters content in surface soil.
- ❑ Off-site stakeholders could also obtain the highest benefit from Measure 1 followed by Measure 2 and Measure 3.
- ❑ Even under Status Quo, off-site stakeholders would still benefit, although the time frame would be longer, i.e., from year 8 onwards.

# Results

## 5. Cost and benefit distributions among stakeholders

Stakeholder groups	Cost distribution (%)				Benefit distribution (%)			
	Measure options				Measure options			
	1	2	3	Status quo	1	2	3	Status quo
1. Local Administration Office	+++	+++	+++	++	+	+	+	+
2. Land owner and Farmers in Maephoon (non-member of any social groups)	+++	+++	+++	++	++	++++	++++	+
3. On-site communities					++	++	++	+
4. Off-site stakeholders (downstream)					+	+	+	+

# Results

## 7. Policy implication

- ❑ The research outputs are needed to be considered from Maepoon Subdistrict Administrative Organization Council for three year developing plan (Year 2012-2014).
- ❑ participation of local community and stakeholders are needed to join public policy formulation, the conflicts during practical implementation of land rehabilitation project could be less.





## **Conclusion**

- ❑ Highest NPV can be obtained from Measure 2, and followed by Measure 3**
- ❑ The least investment for rehabilitation can also be taken by Measure 2.**
- ❑ Measure 2 shows the highest NPV in all cases**
- ❑ The distribution of cost of Measure 2 and Measure 3 was equally to land owners and policy makers**
- ❑ Land owner and farmers would get the most benefit from Measure 3 and Measure 2**
- ❑ Income benefits from banana and fruits produces would be ones of the important incentives for upstream farmers and landholders to rehabilitate agricultural land damaged by landslide**

# ACKNOWLEDGEMENTS



สำนักงานคณะกรรมการพิเศษเพื่อประสานงานโครงการ  
อันเนื่องมาจากพระราชดำริ  
Office of the Royal Development Project Board



The Economy and Environment Program for  
Southeast Asia (EEPSEA)



International Development Research Centre  
(IDRC)

Assoc.Prof. Dr.Orapan Nabangchang-Srisawalak  
and Dr.Herminia Francisco



A lush green forest with a large rock formation in the background. The forest is dense with various types of trees, including tall, thin trees and shorter, broader trees. The rock formation is a large, light-colored rock face with some green moss or lichen on it. The overall scene is a vibrant, natural landscape.

**Thank you very much for your kind attention**