Fundamentals of Ecology

Text by **Toulaphone Keokene**
Drawings by **Kongngern Sengdee**

Pha Tad Ke Botanical Garden - Luang Prabang

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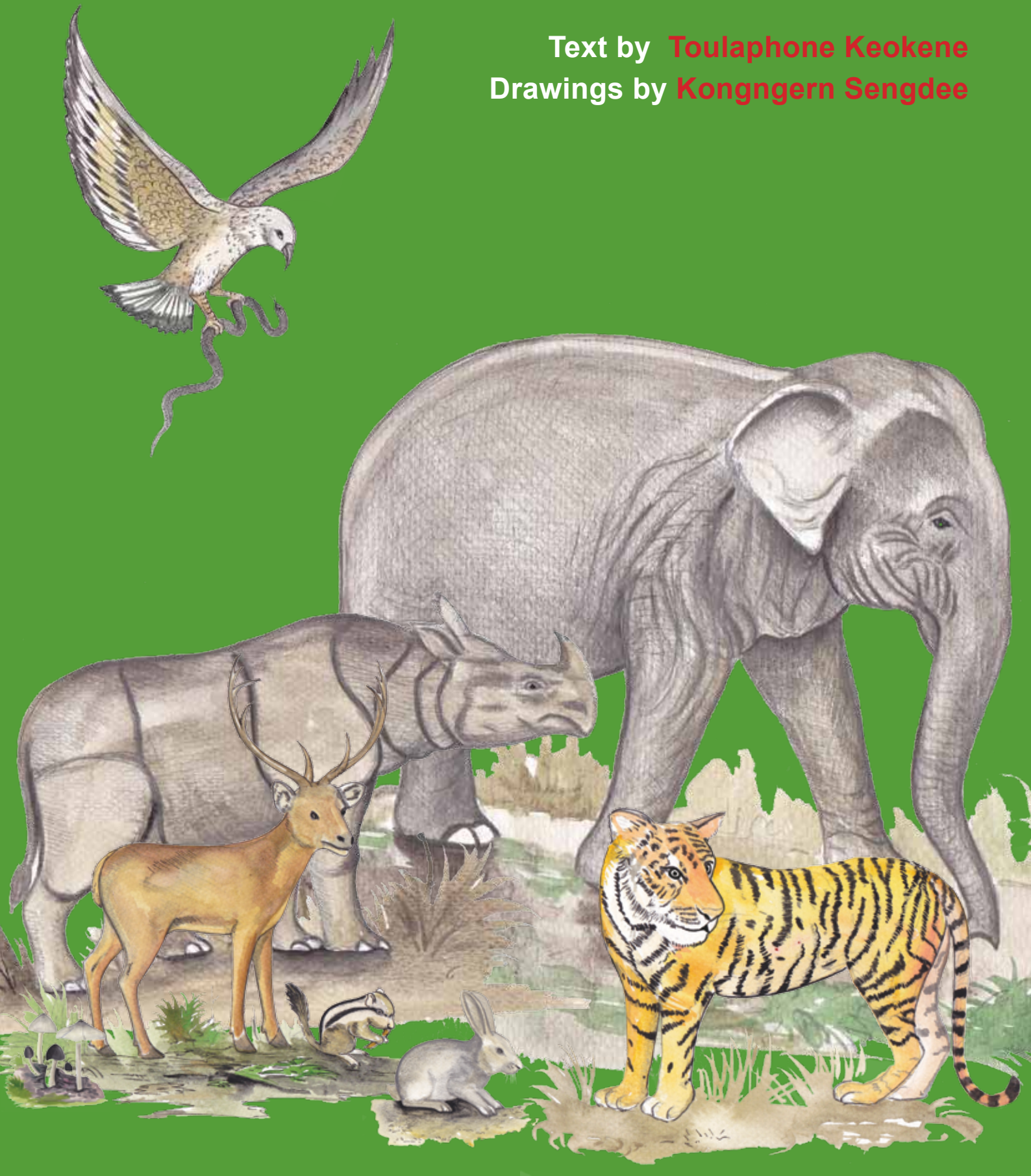


Pha Tad Ke Botanical Garden - Luang Prabang - 2013

Fundamentals of Ecology

Lao PDR is a country full of natural resources of good quality, compared to neighboring countries. These resources represent an important potential for the socio-economic growth of Laos. Therefore it is essential that a lot of effort is put into preserving this heritage for the next generation.

— The new decade and the rapid and continuous growth of scientific and technological knowledge have also helped to develop the country's socio-economic growth. However, human activities have severely deteriorated the environment and resources and this has, in turn, affected human ways of living through: the impact on biodiversity; forest destruction; drought; deterioration of land; increase of waste and harmful chemical products;air, water, land pollution; climatic change, etc.

— This book on the fundamentals of ecology was inspired by the lack of information and books on this subject in Lao language. The only books available are in foreign languages, which make it difficult for anyone who wants to study this field. This book on ecology has thus been written for students and those who are interested in this subject for purposes such as methodology, or as a reference for information sources on all activities linked to the conservation of natural resources.

— The content of this book is divided into 3 parts:

- Chapter One: The Ecosystem, the Cycle of Minerals in the Ecosystem, Biodiversity and the Importance of Rainforest (jungles)
- Chapter Two: Threats to biodiversity and environmental pollution
- Chapter Three: The preservation of natural resources and the environment

— This book will raise awareness of the importance of the ecosystem and all environmental issues among its readers and will provide motivation to protect the environment. It will also encourage all activities related to the sustainable conservation of natural resources, which are a valuable national heritage.

Chapter I: The Ecosystem, the Cycle of Minerals in the Ecosystem, Biodiversity and the Importance of Rainforest (jungles)

I. Introduction

Earth is the source and the place of all living beings and can be called a biosphere or ecosphere. In general, a biosphere is composed of energy and minerals that are ready to be combined into molecules at any time. A natural process then combines living beings and the environment, as well as all living beings in the environment.This process creates the birth, life and activities of minerals and organisms in the environment, which is called an ecosystem, and acts as a structure for the relationships between all elements and the environment. The ecosystem is a concept created by scientists in order to visualize the Earth in its detail and to better understand its mechanisms.

An ecosystem is composed of a population and an environment where this population can live and grow in good conditions. For example, plants and animals need an appropriate place where they can continue to live in a sustainable way.

II. Definition of an Ecosystem

In order to facilitate the understanding of an ecosystem, definitions of terminology will be given below:

- Community: defines more than two varieties of living beings living in the same habitat, such as shrimps, oysters, fish and weeds living in a lake. When living beings of the same variety live in a given place, we call that group a ‘population’.
- Habitat: defines a place where living beings are living, eating, reproducing, raising young, or hiding from any dangers or enemies.

Ecosystem: defines the relationship system between living beings and the environment. In the composition of an ecosystem, it is generally accepted that there are two components: living beings (biotic) and inanimate matter (abiotic).

1. Composition of an ecosystem

The different components of an ecosystem are categorized according to their roles within the system: for example, autotrophs or self-feeding organisms; and heterotrophs, which cannot produce their own food and must eat other organisms to live. But generally speaking, two main components are essential; that is to say biotic and abiotic.

1.1. Biotic Components

Biotic components describe living components of a community. There are three categories of biotic components according to their roles in the system:

1) Producer or autotrophic organismsare living beings able to create food by themselves from simple inorganic substances, and are generally plants that contain chlorophyll.

2) Consumers are living beings which are heterotrophic and cannot produce their own food. This category can be divided into 4 groups as below:

+ Herbivores: animals that consume plants as food, and are considered as primary consumers because they receive direct energy from plants. Examples include: cows, buffalos, sheep, goats, rabbits.
+ Carnivores: animals that consume other animals for sustenance, such as tigers, lions, snakes, etc.
+ Omnivores: animals that consume both plants and animals for sustenance, such as humans, chickens, ducks etc.
+ Scavengers:animals that consume decomposed animals and plants for sustenance,such as vultures, nightcrawlers, caterpillars, termites etc.

3) Decomposers, saprotrophs, osmotrophs and microconsumers are organisms which cannot produce their own food and survive by liberating enzymes to decompose plants and animals into small substances or nutrients that are useful for the saprotroph, such as bacteria, fungi, and actinomycetes.
If there were no saprotrophs, dead plants and animals would never decompose and would keep piling up until the Earth was full. Decomposition is the linkage key in the ecosystem.

Fungi, which can aid decomposition in the ecosystem

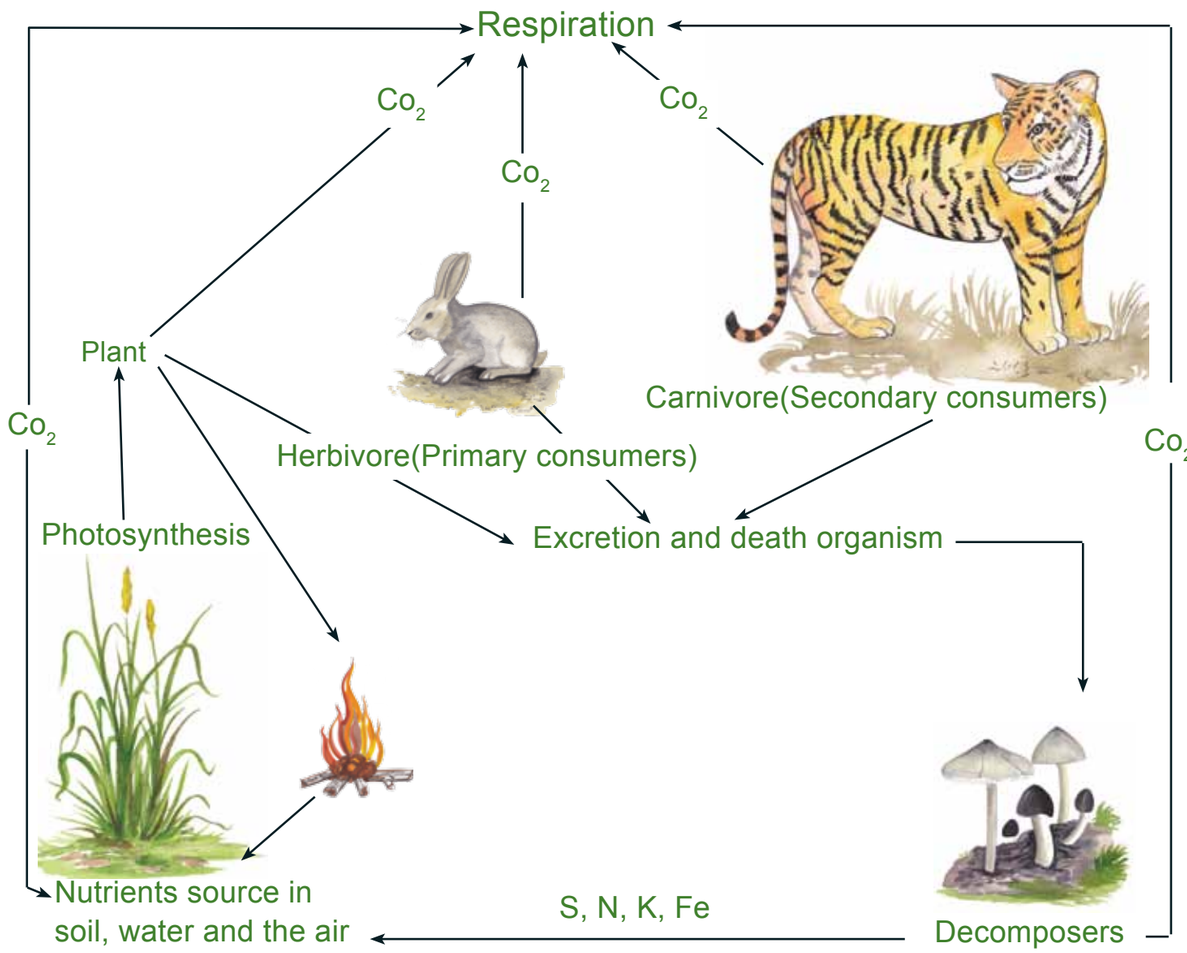
1.2. Abiotic Components

1) Inorganic substances are composed of minerals and substances that are essential for life such as carbon, oxygen, nitrogen, carbon dioxide, and water. These components are circulating in the ecosystem and are called the biogeochemical cycle.

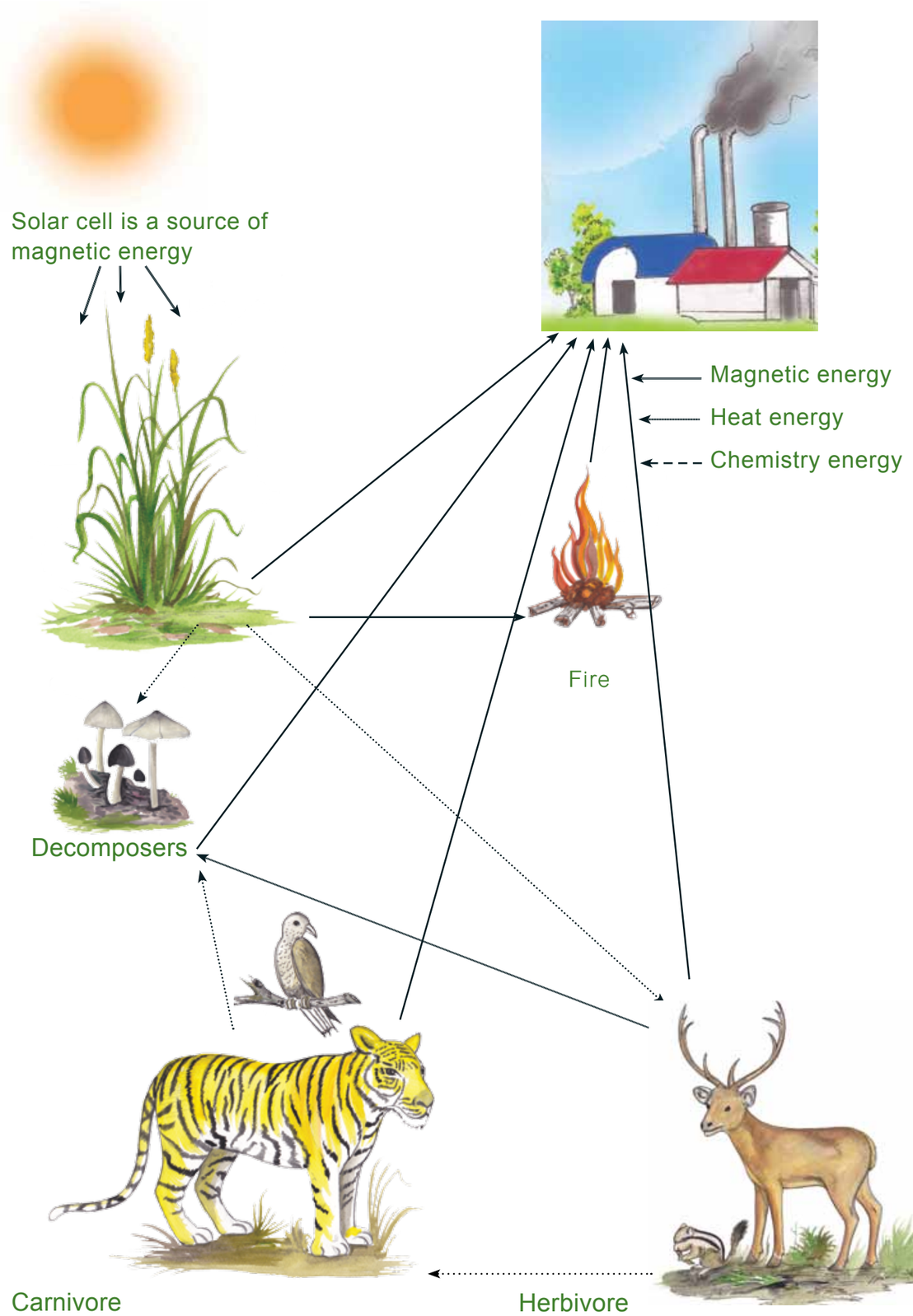
2) Organic compound defines compounds that are essential to life such as proteins, carbohydrates, cholesterol, humus, etc.
3) Climate regime is the combination of physical factors that influence the life of the ecosystem. If one of these factors is missing, life cannot exist. These factors are called limiting factors or climate regimes.
For example:
— Temperature influences the metabolism of plants and cold blooded animals. It also impacts the migration patterns of warm blooded animals and the propagation of various plants and animals.
— Clear light influences the photosynthesis of plants, the blooming of flowers and fruits, and the behavior of animals towards food.
— Humidity (water) influences the propagation of plants and animals and all types of organisms.
The main two processes of an ecosystem are the energy flow and chemical cycling. Energy flow is the transfer of energy in the ecosystem. Chemical cycling is the use and the recycling of minerals in the ecosystem such as carbon and nitrogen.
The energy that is sent to the ecosystem is generally visible in the form of solar energy. Plants and other producers will transform solar energy into chemicals in the form of energy-providing food such as carbohydrates. The energy is transferred to animals through the ingestion of plants. Another form of energy is heat created in the ground by the decomposition of plants and animal carcasses by important decomposers such as bacteria and fungi. This heat can be recycled in the ecosystem.
The energy and chemicals cycling through the ecosystem can be reused by the community of organisms and the abiotic environment.
All living beings need carbon, nitrogen, and other minerals that can be found in the form of inorganic substances in the atmosphere and the ground.

Photosynthesis recombines those minerals into other forms such as carbohydrates and proteins. Animals then receive them through the ingestion of these plants and other animals. Respiration splits molecules of organisms into carbon dioxide and water.

The mineral cycle completes when microorganisms decomposes dead matter and waste, such as faeces and leaves. Freed minerals are stored in the earth, water, and atmosphere in the form of inorganic substances that plants and producers use to recombine into new molecules. The cycle then repeats itself.



The process of transmitting food minerals in the ecosystem

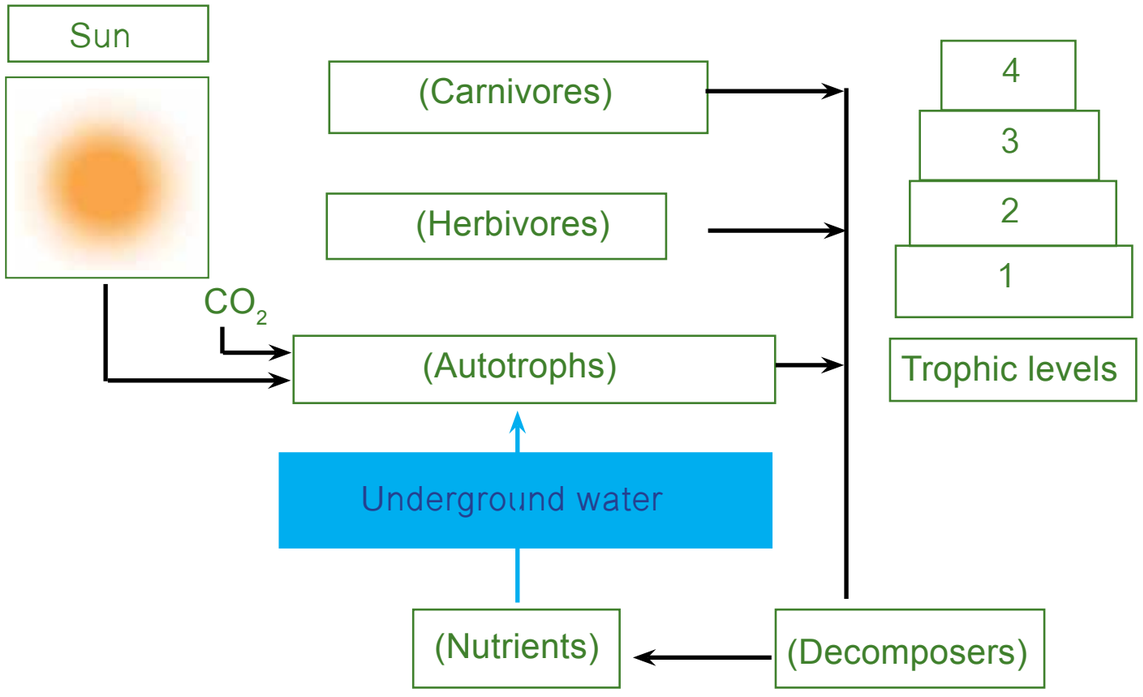


Transmission or movement in the ecosystem

2. Trophic Levels

The relationship of food is the path followed by the energy and chemical cycles in the ecosystem. Based on a study of diets in the ecosystem, scientists are able to classify the type of ecosystem according to the source of food at trophic levels.

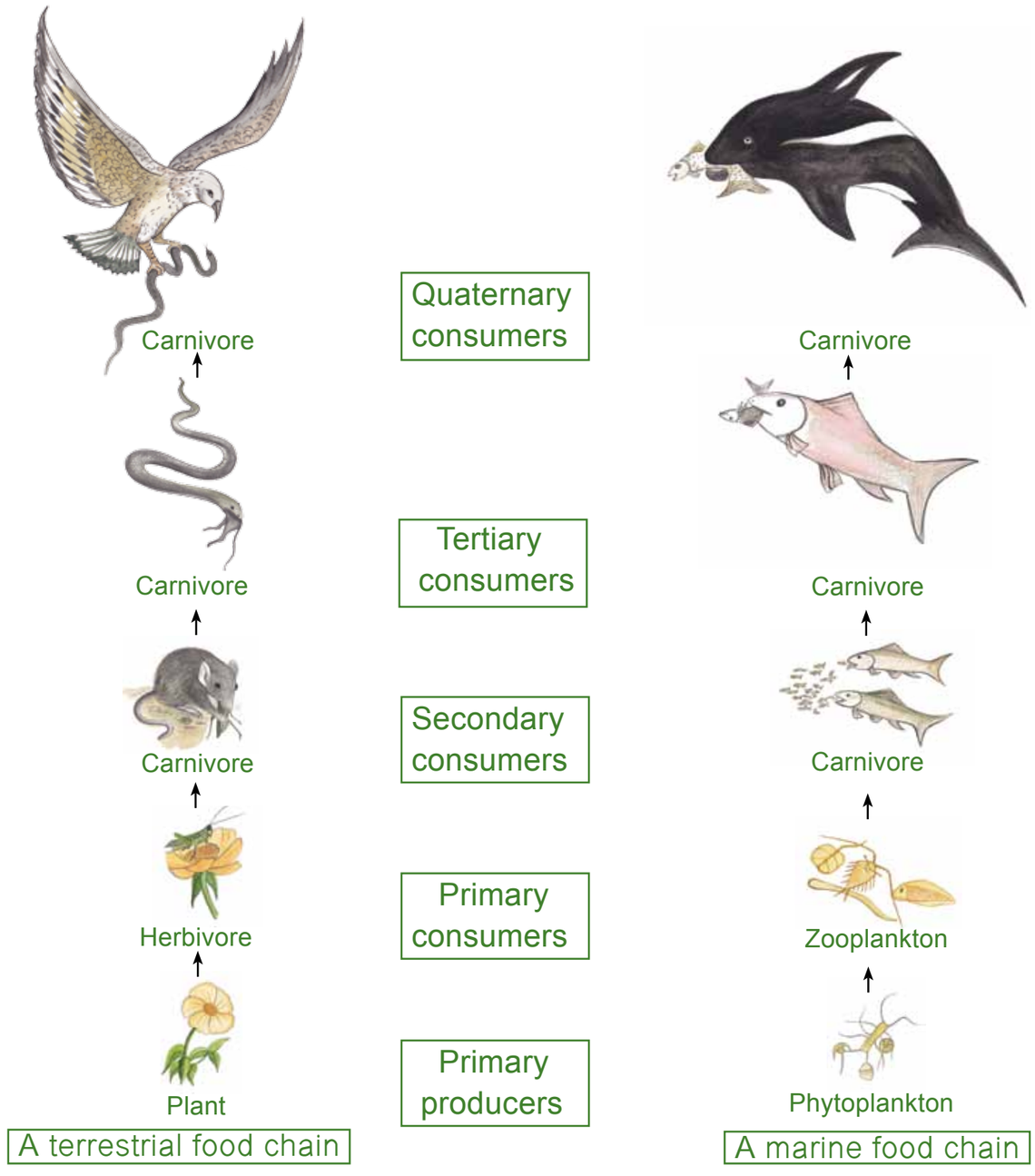
The food chain can be seen by following the arrows from the plants of the producers to the first herbivore, to the second and third consumers, and finally the fourth and last carnivore.



Relationship between trophiclevels in the eco-system

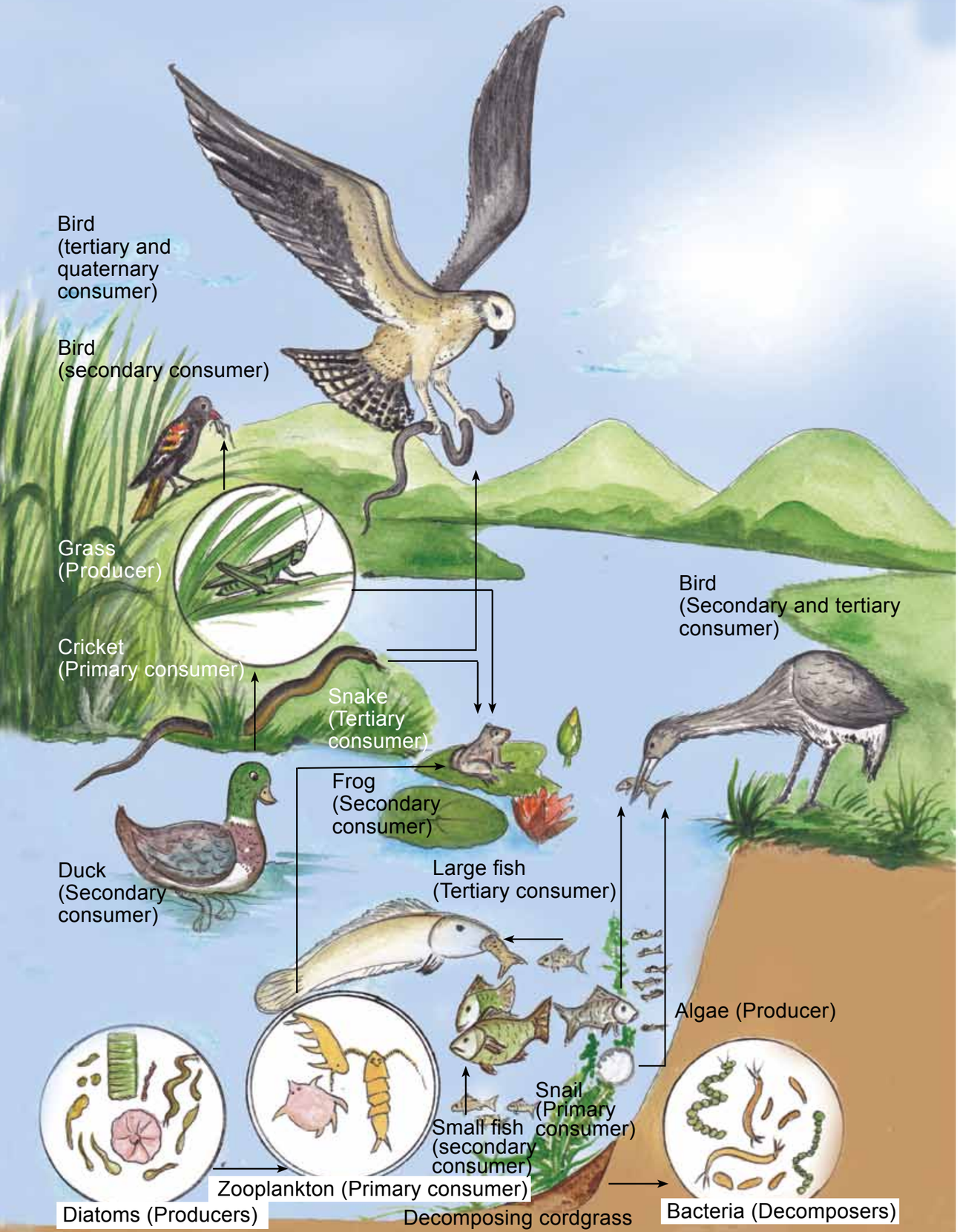
Food Chain

The food chain is the relationship between living beings in the ecosystem that eat each other as a chain, in order, with a transmission of energy up the chain, as can be seen in picture 5:



Food chain for terrestrial and maritime animals

Transmission of food in the food web model



2.1. Food Web

The food web is the relationship between living beings in the ecosystem that eat each other. This is a complex relationship because each living being can eat different kinds of food and can become food for another animal which also eats many types of food.

Therefore, the food web is composed of many food chains that are integrated, such as below:

3. Interspecies Interactions in a Community

All living beings in the same community have interactions, which can be either symbiotic or competitive. Three types of interactions are identified: competition, predation and symbiosis. All three types of interaction play different roles in the environment. To have a better understanding of population change in the environment, it is important to understand the evolution of adaptation, and the interaction between all living beings.

3.1. Competition between species occurs when two or more populations or communities with similar needs inhabit an area with limited resources.

3.2. Predation is the act of one living being hunting, killing and eating another living being for survival. Examples of predator and prey are cats and mice, tigers and deer, etc. But a predator can also be the prey of another living being. For instance, frogs eat insects and lizards eat frogs. The predator is the beneficiary, not the prey.

+ One could classify plants as the prey of an herbivore. As plants can't flee from their predators, they have other methods of protection such as thorns. Some plants produce chemicals such as nicotine and morphine, or even imitate animal hormones. When ingested, these substances can cause growth and development problems or even death.

+ Animals have many ways to protect themselves from predators such as fleeing, hiding etc. Flight is the most common technique used by most animals. Moreover, there are other techniques such as sound alerts, imitation, tricks, or even fighting in groups to chase predators away.

3.3.A symbiotic relationship is an interaction between two communities in which one is called symbiont and the other is called host.
There are three types of symbiotic relationships: parasitism, mutualism and commensalism.

3.3.1.Parasitism: In this kind of relationship, one benefits and the other does not. For example, an intestinal worm and a human living together constitutes parasitism. The parasite (the worm) in this case does not want the death of its host because if the host dies, it will also die. According to its living conditions, there are two types of parasitism:

a. Endoparasite: The parasite lives and eats inside the body of a host. Examples include intestinal worms, tape worms etc.

b. Exoparasite: The parasite lives outside the body of a host, for example lice, ticks, scabies, etc.

3.3.2.Mutualism is a relationship between two communities where both parties benefit and cannot be separated, otherwise both die. An example of mutualism is lichen, composed by fungi and algae. Another is protozoa living in the intestines of termites.

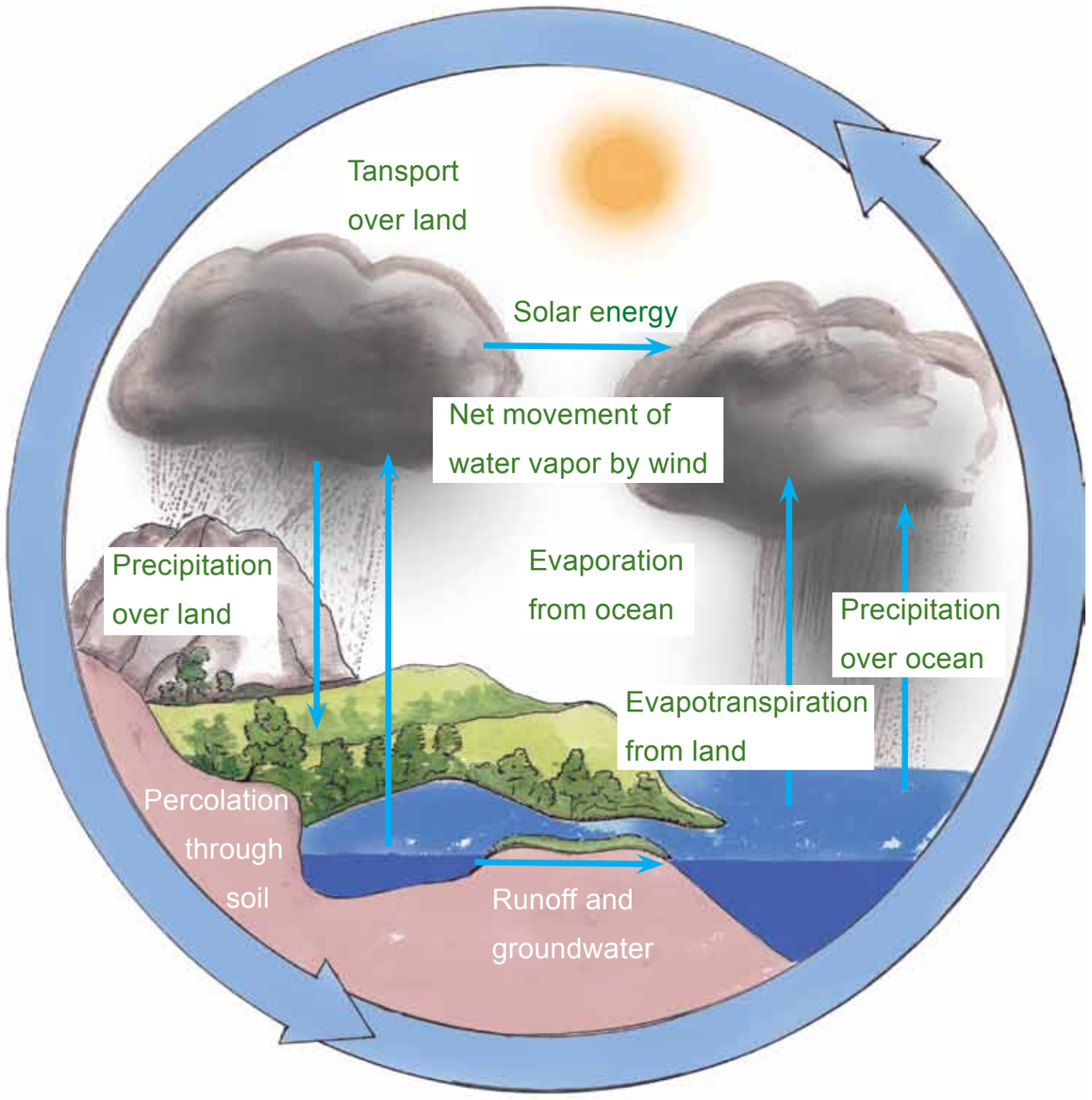
3.4. Commensalism is a relationship where one party benefits and the other may benefit or not, such as wild orchids and trees.

II. Material Cycles in the Ecosystem

Living beings can live in this world if they are involved in the mineral cycling of the ecosystem and if there is energy transmission. There are many minerals but the ones that are essential to life are classified according to the quantity of components in living organismsand are divided into 3 groups as below:

Table 1: Comparative table on the quantity of elements forming living organisms (Kupechella and Hyland, 1989)

High mineral quantity required (>1% of dry weight)		Mineral quantity between (0.2-1% of dry weight)		Low mineral quantity required (<0.2% of dry weight)	
Element / Symbol		Element / Symbol		Element / Symbol	
Carbon	C	Calcium	Ca	Aluminium	Al
Hydrogen	H	Chlorine	Cl	Boron	B
Nitrogen	N	Copper	Cu	Bromine	Br
Oxygen	O	Iron	Fe	Chromium	Cr
Phosphorus	P	Magnesium	Mg	Cobalt	Co
		Potassium	K	Fluorine	F
		Sodium	Na	Gallium	Ga
		Sulfur	S	Iodine	I
				Manganese	Mn
				Molybdenium	Mo
				Selenium	Se
				Silicon	Si
				Strontium	Sr
				Tin	Sn
				Titanium	Ti
				Vanadium	V
				Zinc	Zn



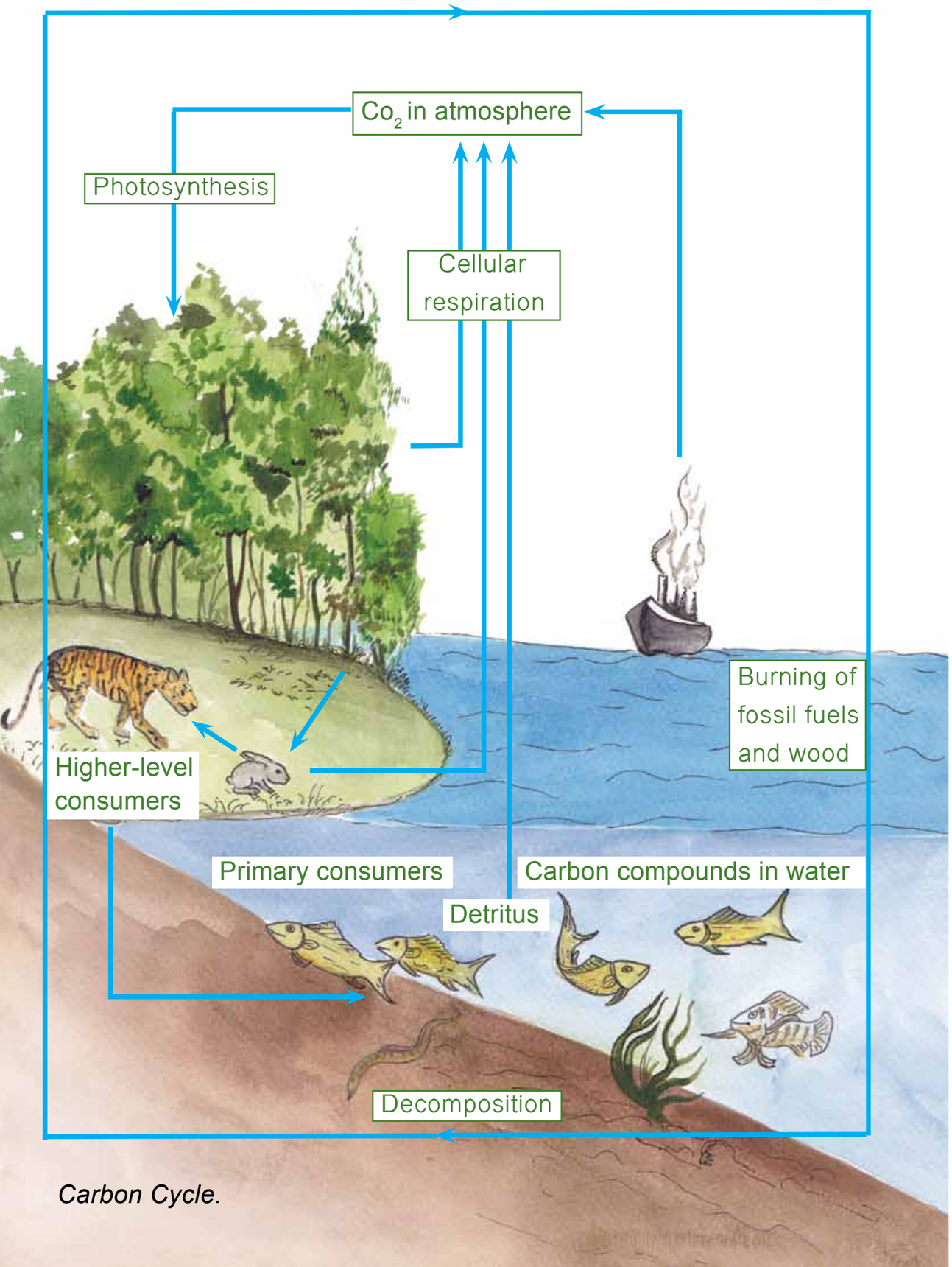
Water Cycle.

The cycles of minerals are classified into 3 groups: hydrologic cycles, atmospheric cycles and lithospheric cycles.

a. Hydrologic cycles are the cycles of water in the different parts of the Earth.
b. Atmospheric cycles are the cycles of minerals that have been accumulated in the atmosphere in the form of vapor. Carbon finds its source in the atmosphere, generally in the form of carbon dioxide (CO2) or nitrogen vapor (N2, NO, NO2).
c. Lithospheric cycles are the cycles of minerals that are generally located in the sediment, rocks and land. The sources of accumulated minerals are generally phosphorus and fluoride.

II. 1. Water Cycle

Water is a renewable resource. 97% of water is in oceans and the other 3% is in the poles, rivers and watercourses, and underground aquifers. The hydrologic cycle starts with the sun that shines on the Earth. The energy given off by the sunlight causes evaporation and plants transpiration. When water vapor is in contact with cold air, it condenses and is recycled into rain that falls on the ground and oceans. This water cycle is stable in a well balanced environment, but nowadays this balance is changing because of forest destruction and greenhouse effects.

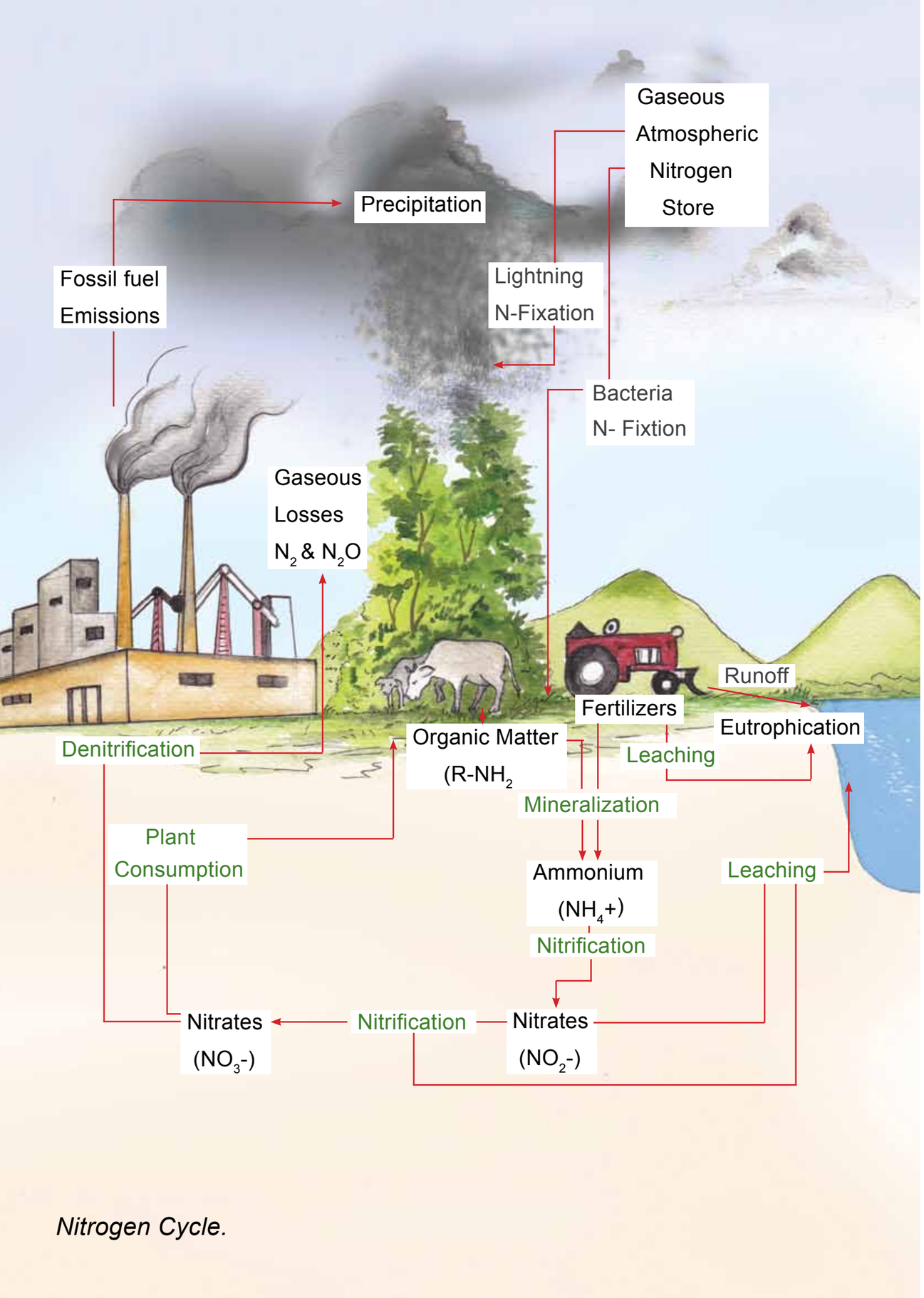


Carbon Cycle.

II. 2. Carbon Cycle

Carbon is an element that is found in all substances. Therefore, the cycle of carbon is often in interaction with other cycles in the ecosystem. It is an important component of substances that are present in other living beings such as: carbohydrates, protein, cholesterol, and vitamins. The carbon cycle refers to carbon dioxide gas coming from the atmosphere, entering the body of living organisms and being released into the atmosphere and. The cycle is infinite as carbon dioxide gas present in the atmosphere and water is transferred to living beings through a chemical process linked to plants. Carbon dioxide is then transformed into energy.

Carbon dioxide then enters the body and is released back into the air through plants and respiration, the natural destruction of animal secretions, plants remains and animal carcasses, and combustion of coal, gas, and limestone.



Nitrogen Cycle.

II. 3. Nitrogen Cycle

All living beings need nitrogen in order to produce proteins for growth. Even though up to 78% of nitrogen is available in the atmosphere, plants and animals cannot use nitrogen in this form.

It must be transformed into ammonia, nitrite, or nitrate first.

Therefore, atmospheric nitrogen has to be modified into a form that most living beings can ingest. This cycle is mainly marked by ammonification, nitrification, and denitrification. These processes need bacteria and other microorganisms in large quantities in order to create a balance in the nitrogen cycle. There are two different types of fixation for nitrogen:

1) Electrochemical and photochemical fixation

This process needsa strong electrical charge such as lightning, as high levels of energy are required to change nitrogen present in the atmosphere into a form which will be tolerated by living beings.

2) Biological fixation

Some organisms such as bacteria and some types of plankton are able to capture and fix nitrogen and modify it into nitrate. Two types of fixers can be found:

a. symbiotic nitrogen fixers

Usually bacteria and fungi. The most famous one is the bacteria Rhyzobium, which can be found in some roots, living in a symbiotic relationship.

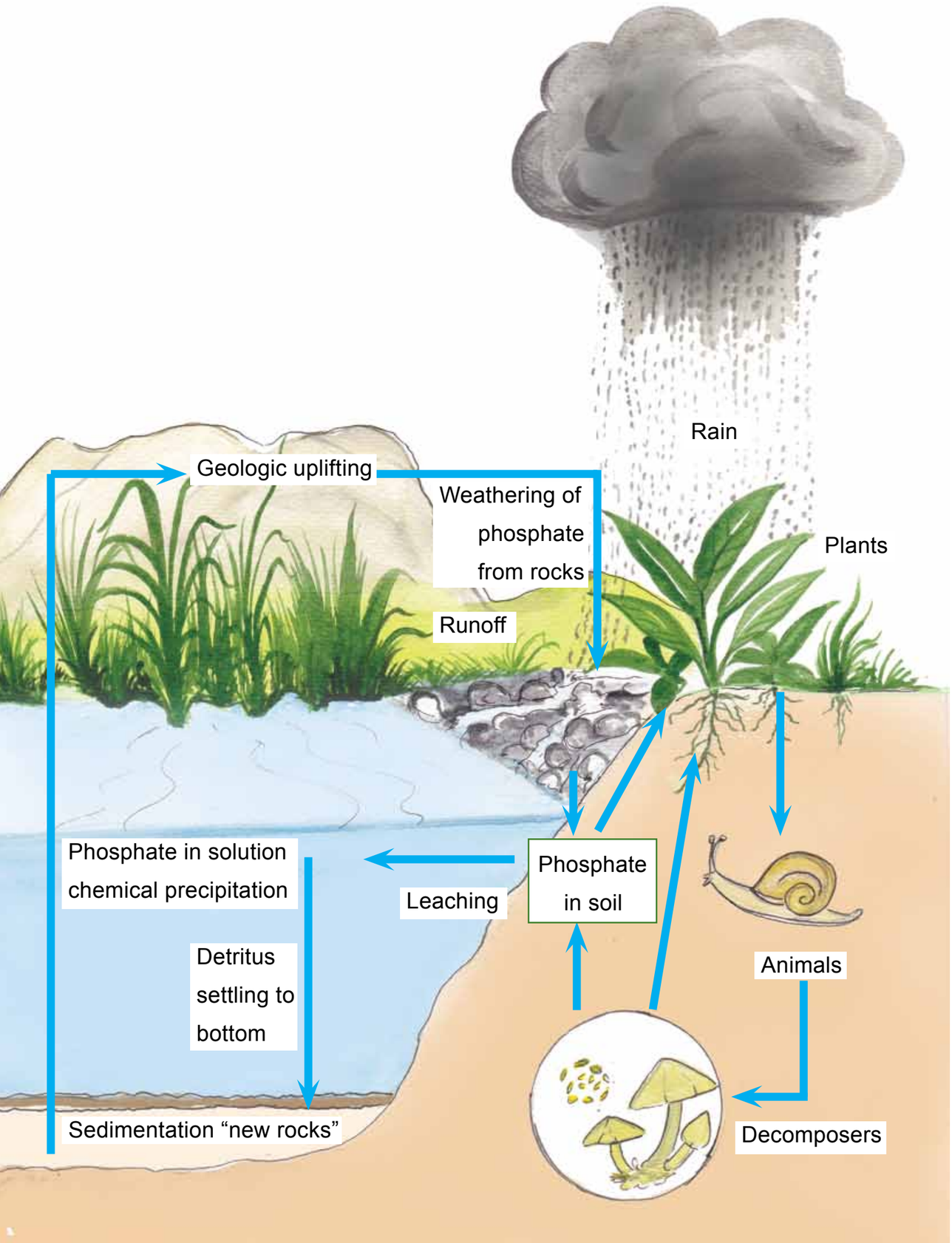
b. free living nitrogen fixers

Planktons (grey, green and blue), bacteria, and yeast such as:

+ Planktons: Anabaena, Nostoc, Tolyphothrix, Thricodemium, Osicillatoria and Lyngbya etc.

+ Bacteria: Azotobacter, Clostridium, Rhodosperillum and Bacillus.
Yeast: Rhodotorula and Pullularia, etc.

Phosphorus Cycle.



3) Ammonification

The process of disintegration of amino-acids or protein into ammoniais initiated by bacteria called ammonifying bacteria such as Pseudomonas and Proteus. This process is thus called ammonification, which means the transformation from amino-acid or protein into ammonia.

4) Nitrification

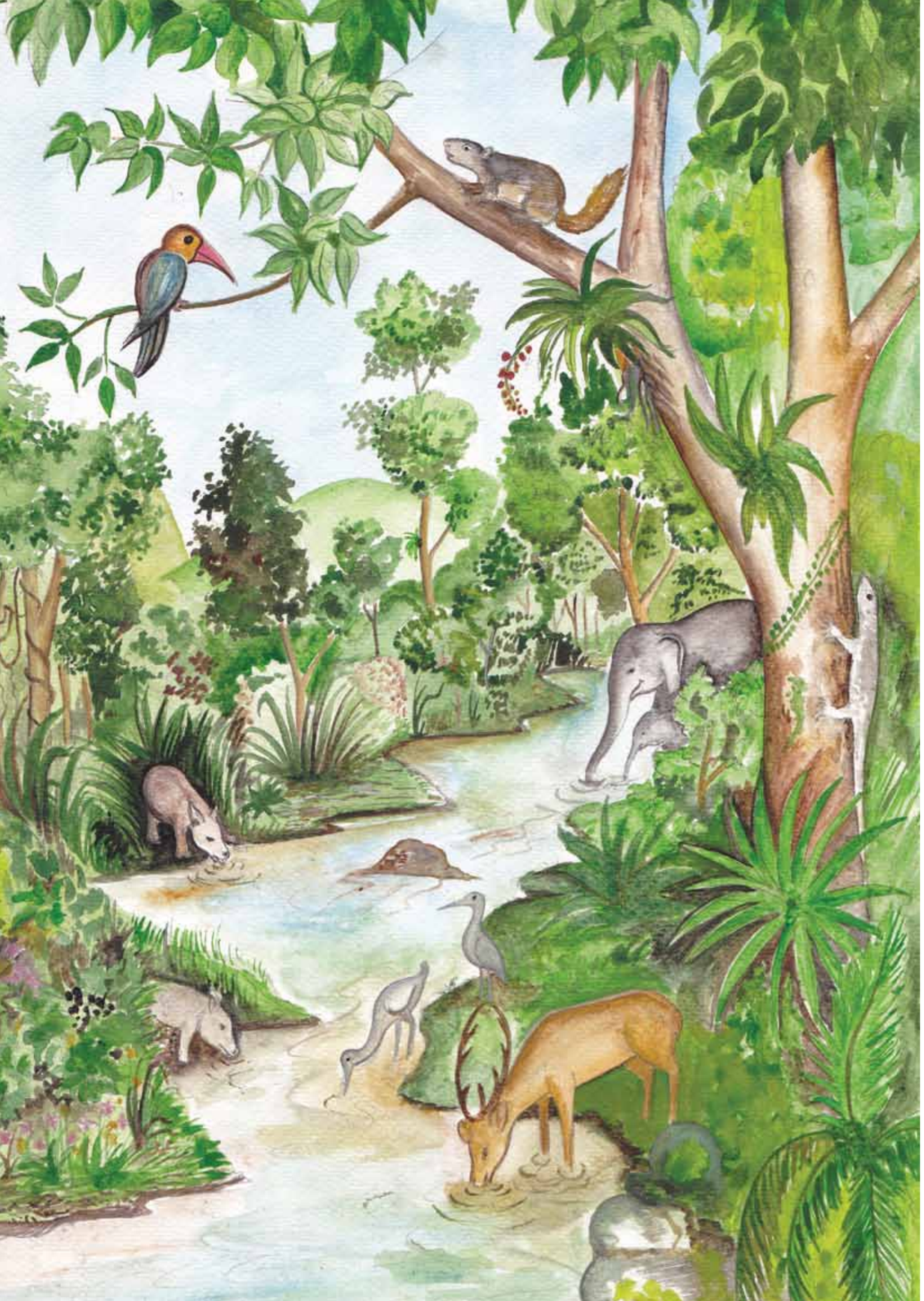
Secretions made by plants or animals that reach the stage of ammonia are modified by nitrobacteria such as Nitrosomonos into nitrites, which are then modified again into nitrate by nitrate bacteria such as Nitrobacter. This phenomenon is called Nitrification.

5) Denitrification

Plants can use nitrate directly and are able to change nitrates back into amino-acids and proteins, which will be then transformed into nitrogen while in contact with the atmosphere, by relying on a denitrifying bacteria such as Pseudomonas, Thiobacillusor Micrococcus denitrificans. This process is called denitrification.

II. 4. Phosphorus Cycle

The phosphorus cycle is essential to life. Phosphate is a component of nucleic acid, phosphoproteins and phospholipids. Moreover, calcium phosphate is the main component of bones and teeth. Phosphate fertilizers are important for the normal growth of plants. The cycle occurs when soluble phosphate is used by plants and is bound into organic compounds. When the plant is eaten by animals, phosphate is transferred. When plants and animals decay, phosphate is then returned to the soil and water.



IV. Biodiversity

1. Definition of biodiversity:

Biodiversity refers to the variety of plant and animal species in an environment or ecosystem.

One of the miracles of the system is the variety of living beings that comes from the interaction between species and the environment in a continuous and sustainable way.

— The variety of biodiversity can be found at many levels: species diversity such as microorganisms, plants and animals, including humans. All living beings are conditioned by numerous organisms (genetic diversity) fitting in the living environment of each species, and constituting a complex ecosystem (ecological diversity).

— There are two main characteristics in the variety of species of living beings. One is species richness, which refers to the number of species represented in a set or collection of individuals. The other is species evenness, which refers to how close in numbers each species in an environment is to other species. These two characteristics together constitute the definition of biodiversity.

— Scientists expect that there are between 5 to 30 million species, classified into micro-organisms (microbes), plants and animals. About 2 million species have been scientifically studied. Out of those 2 million species, only 0.01% has been analyzed to see how those species directly or indirectly benefit humans.

For example, among the analyzed species, there are 1,000 species of viruses, 4,760 species of bacteria, 26,900 species of algae, 30,800 species of monocellular animals, 99,000 species of invertebrate animals and 44,000 species of vertebrate animals disseminated throughout the world. The population numbers and the number of species in any given ecosystem are very different, based on their environment and habitat.

V. The importance of rainforests

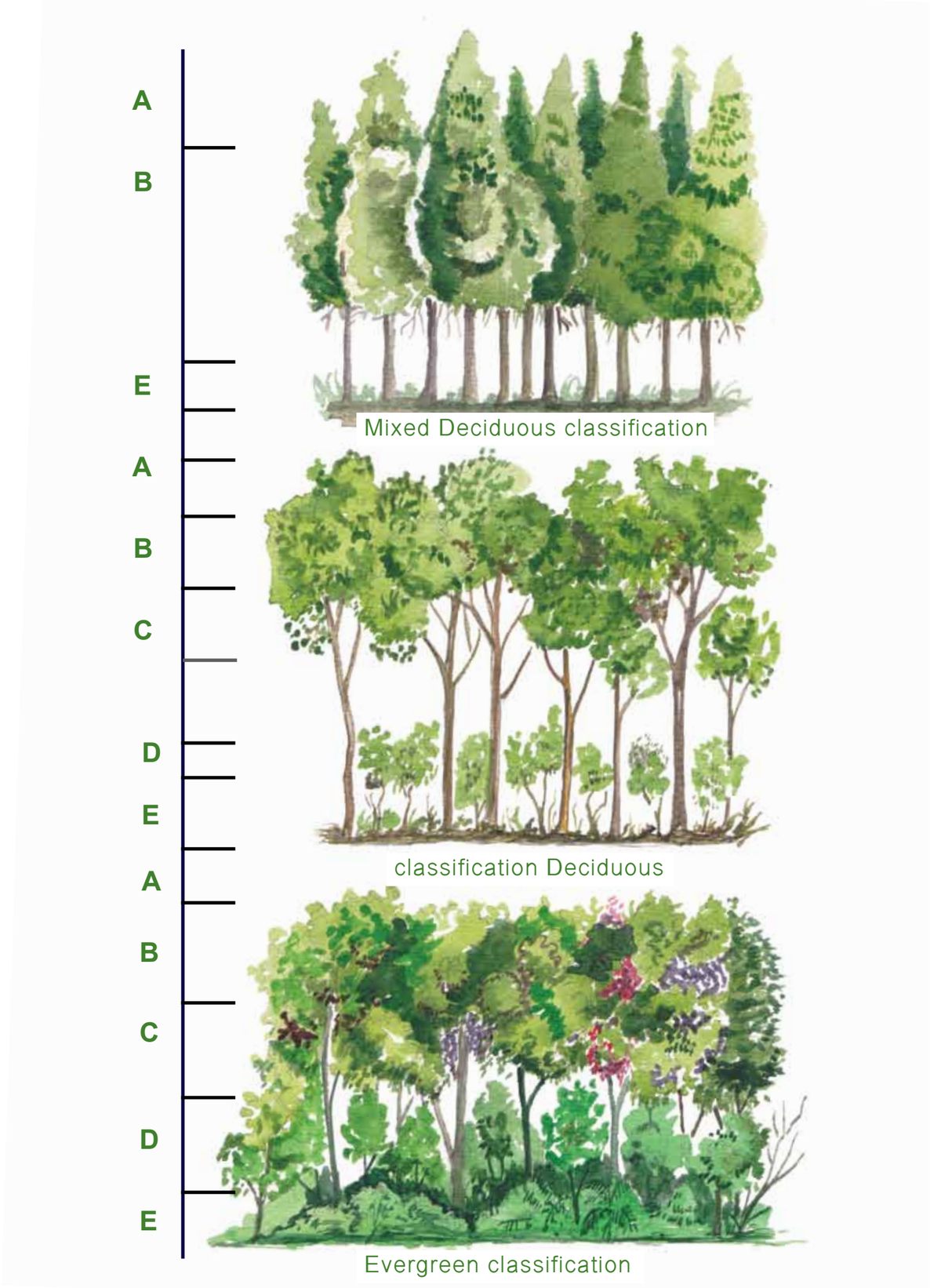
Large rainforests which are located around the equator can primarily be found in South and Central America, Southeast Asia, and North Australasia. Rainforests are considered the most complex ecosystems in the world and are full of biodiversity.

These forests are being destroyed at a very dangerous pace, despite their importance. Rainforests represent 10% of the total surface of the globe and 50-70% of plants and animals inhabit this ecosystem. They represent an important source of natural resources such as medicine and food. At least 1,650 varieties of plants are used as food components. The largest rainforest in the world is the Amazon forest in Brazil.

1. The different layers of the forests

Tropical rainforests have approximately the same structure and are typically divided into 5 layers, each with different plants and animals living together. Some rainforests have less than 5 layers.

Some trees are 50-60 meters tall, but in general are on average 30-40 meters. The overlapping branches and leaves of these trees form the canopy of the forest,which can be divided into 3-5 different layers according to height (A, B, C, D and E), A being the highest, surpassing the other trees by at least 10-15 meters. Eagles and other predatory birds inhabit this layer, looking for prey to attack. B is the next layer, about 30-40 meters above ground level. This layer is approximately 10 meters thick and is complementary to layer A. Therefore, these two layers act as an almost perfect umbrella to protect the lower layers of the forest. The next layer is C, which is composed of the lowest trees. Layer D includes bushes, young trees, large ferns, etc. The last layer is E and it is slightly higher than ground level and includes young trees, seedlings, etc.



The classification of tree in 3 types of community forests (Smith, 1974)

2. Types of forests in the Lao PDR

There are two main classifications of vegetal communities in South East Asia and more specifically Lao PDR: rainforests and deciduous forests. Rainforests can be subcategorized into many varieties such as tropical rainforests, dry rainforests, mountain rainforests, etc. Deciduous forests can also be subdivided into many categories such as deciduous mixed forests, dry dipterocarp forest (stony forest), etc. Moreover, there are still many other types of forests such as pine forest, wild moor and swamp forest.The classification of forests and their coverage in Lao PDR has been detailed in the table 4.1 below according to several evaluations initiated by the National Office of Forest Inventory and Planning of the Department of Forestry, Ministry of Agriculture and Forestry in 1992.

Table 2: Total area of the different types of forests in Lao PDR

Type of forests	Area (ha)	% of country
Dry Dipterocarp	1.207.680	5,1
Lower Dry Evergreen	94.720	0,4
Upper Dry Evergreen	1.065.600	4,5
Lower Mixed Deciduous	852.480	3,6
Upper Mixed Deciduous	7.459.200	31,5
Gallery Forest	94.720	0,4
Coniferous	118.400	0,5
Mixed Coniferous/Broadleaved	284.160	1,2
Sub Total Forest Cover	11.176.960	47,2
Total Nonforest Cover	12.503.040	52,8
Total Land Area	23.680.001	100,0

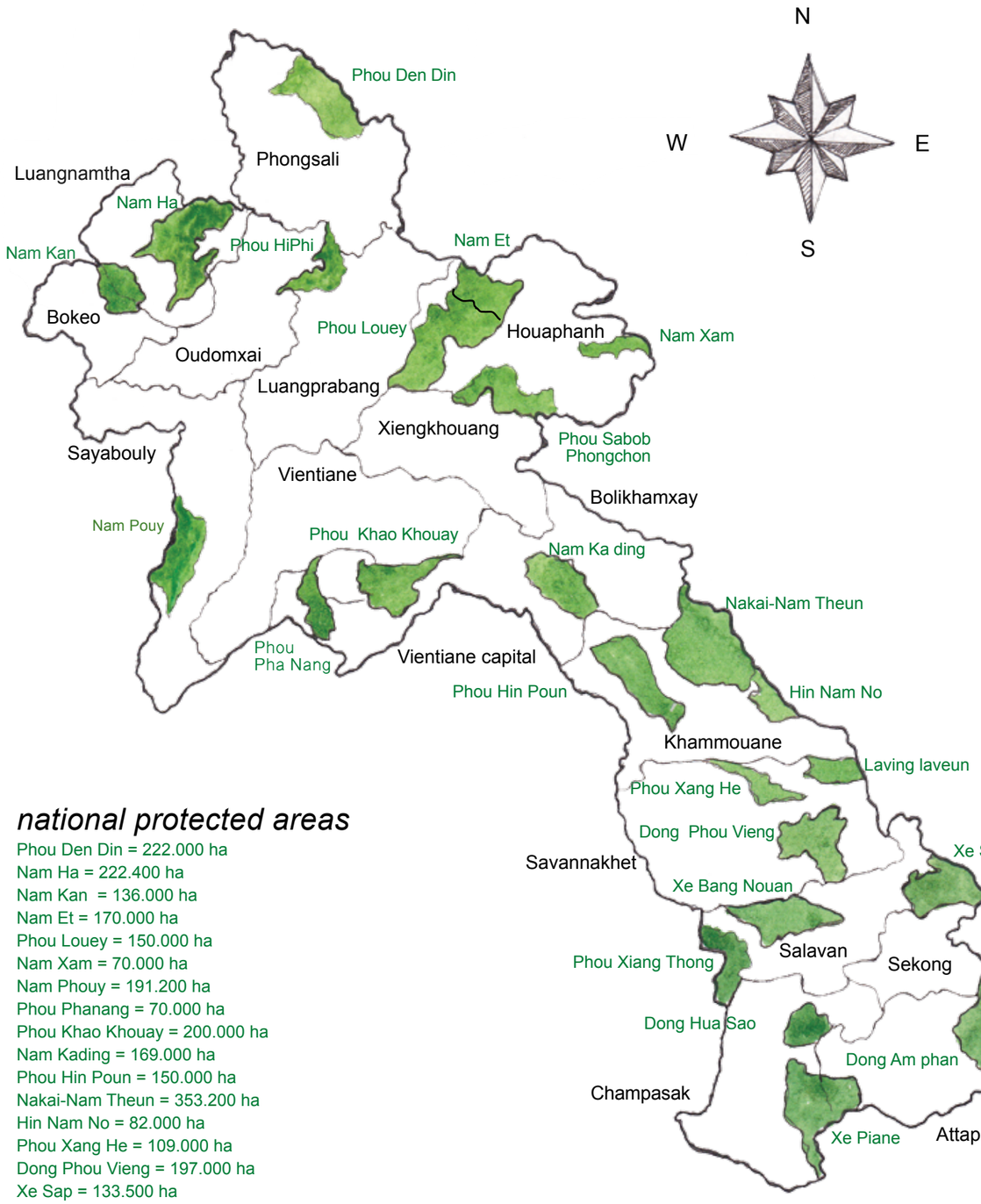
Source: National Office of Forest Inventory and Planning, 1992

3. National protected forest areas in the Lao PDR

Almost 68% of Lao territory is covered by original forests; 23% are mixed forests and 7% are dry dipterocarp forest (*Lao PDR National report on protected forests and economic development*, 2003, based on MacKinnon, 1986). The government figure for forest coverage in the country was 47% in 1998 (according to the 2001 survey). The World Bank estimates that of 80% of all forested areas, more than half of them are very deteriorated and are not included in the calculation of the percentage of forest coverage (World Bank 2011, based on *Lao PDR National report on protected forests and economic growth*, 2003). Anyway, these figures are not definite and the government is still actively working on determining the percentage of forest coverage. Even if DTZMRC reports that forest coverage is only 39,7%, this has not yet been validated by the Lao government. One certainty is that the Lao government implemented a national protected forest areas system in 1993, which included 20 areas, representing 12,5% of Lao territory. At the provincial level, this represents 8,5% of the territory, making 21% of the country protected forest areas, which is one of the highest percentages in the world (IUCN in Lao PDR, 1999). Now, there are a total of 24 protected forests disseminated throughout the country, as can be seen in the table below.

No	Name of protected forests	Area (Ha)	Year of approval	Location
1	**Phou Den Din**	222.000	29.10.1993	Phongsaly
2	**Nam Ha**	222.400	29.10.1993	Luang Namtha
3	**Nam Kan**	136.000	29.10.1993	Bokeo
4	**Nam Att**	170.000	29.10.1993	Huaphan
5	**Phou Lei**	150.000	29.10.1993	Huaphan / LPB / XKH
6	**Nam Sam**	70.000	29.10.1993	Huaphan
7	**Nam Pouy**	191.200	29.10.1993	Xayabouly
8	**Phou Phanang**	70.000	29.10.1993	Vientiane / Vientiane Capital
9	**Phou Khao Khuay**	200.000	29.10.1993	VTE / VTE Cap / Bolikhamx ay
10	**Nam Kading**	169.000	29.10.1993	Bolikhamxay
11	**Phou Hinpoun**	150.000	29.10.1993	Khammouan
12	**Nakai-Namtheun**	353.200	29.10.1993	Bolikhamxay / Khammouan
13	**¬Hin Nam Nor**	82.000	29.10.1993	Khammouan
14	**Phou Xanghae**	109.900	07.07.1996	Savannakhet
15	**Dong Phuvieng**	197.000	1995	Savannakhet
16	**Xesap**	133.500	29.10.1993	Salavan / Sekong
17	**Xebangnuan**	150.000	29.10.1993	Savannakhet / Salavan
18	**Dong Huasao**	110.000	29.10.1993	Champasak
19	**Phu Xiengthong**	120.000	29.10.1993	Salavan / Champasak
20	**Xepian**	240.000	29.10.1993	Champasak / Attapeu
21	**Dong Ampham**	200.000	12.05.2008	Attapeu
22	**Phousabod-Poung Chon**	149.000	10.12.2009	Xieng Khouang
23	**Phou Hiphi**	87.350	25.02.2011	Oudomxay
24	**Laving Laveun**	86.000	25.02.2011	Savannakhet
	Total	3.768.550		

Table 3: The 24 national protected forests in the Lao PDR



national protected areas

Phou Den Din = 222.000 ha
Nam Ha = 222.400 ha
Nam Kan = 136.000 ha
Nam Et = 170.000 ha
Phou Louey = 150.000 ha
Nam Xam = 70.000 ha
Nam Phouy = 191.200 ha
Phou Phanang = 70.000 ha
Phou Khao Khouay = 200.000 ha
Nam Kading = 169.000 ha
Phou Hin Poun = 150.000 ha
Nakai-Nam Theun = 353.200 ha
Hin Nam No = 82.000 ha
Phou Xang He = 109.000 ha
Dong Phou Vieng = 197.000 ha
Xe Sap = 133.500 ha
Xe Bang Nouan = 150.000 ha
Dong Hua Sao = 110.000 ha
Phou Xiang Thong = 120.000 ha
Xe Piane = 240.000 ha
Dong Amphan = 200.000 ha
Phou Sabod -Poungchon = 149.000 ha
Phou Hiphi = 87.356 ha
Laving laveun = 86.000 ha

The distribution of national protected forests in Lao PDR

Chapter II: Threats to Biodiversity and Environmental Pollution

1. Threats to Biodiversity

In recent decades humankind has controlled the world more than any other species. Increasing population and rapid economic growth are the main reasons for the use of natural resources. One third to half of the land in the world has changed because of human activities (Vitousek et al. 1997). Moreover, humans have modified the roles of natural systems in many ways such as the change in the world atmosphere by freeing carbon dioxide (CO_2) from industrial factories, which is one of the main causes for the continuous global climatic warming, together with the destruction of ozone by chloroflurocarbons or CFCs, which is a gas created by humans. Direct threats to biodiversity are a problem that the world is facing now. These threats include the disappearance of living space, the appearance of organisms attacking biodiversity, pollution, excessive exploitation of natural resources, and climatic changes. Moreover, the increase in population, immigration, poverty, increases in land use, and poor implementation of rules and regulations are also reasons for the extinction of biodiversity.

— The loss and separation of habitats also represent an important threat to animals living in forests and plant species throughout the world and are still the original cause of biodiversity extinction (Rosenburg and Raphael 1986; Wilcox and Murphy 1985). Habitats for plants and animals are affected by natural phenomena such asearthquakes. Humans are the main threat as they have greatly modified nature to their advantage for many years, for example through agriculture. Nowadays, agricultural activities are the main cause of general destruction of biodiversity.

— Invasive species: are species harming the preservation of biodiversity everywhere in the world. The threat, at a basic level of species, is ranked second when compared with the threat at the ecosystem level. Moreover, when we move a certain species from a place in the world to another area in the world, it will be a serious threat to the biodiversity of the world and the evolution of new species.

— The use of non-timber forest products in the Lao PDR: our country is well-endowed with forests and natural resources. The fundamentals of our self-sufficient economy are based primarily on natural resources. More than 85% of the population lives in rural areas, practicing agriculture and picking non-timber forest products.

Lao Name	Scientific name	Part utilized	Type of utilization
Het bod (Kra-dang mushroom)	*Lentinus polychrous*	Every part	Food
Mak khor (Taraw palm fruit)	*Livistona saribus*	Fruit	Food
Hua koy (Intoxicating yam)	*Dioscorea hispida*	Head	Food
Phak waan pa (Wild tree)	*Melientha suavis*	Young leaves, fruit, flower buds	Food
Kheua khaow khor	*Tinospora crispa*	Stem	Medicine
Ya hua (Tufuling)	*Smilax glabra*	Head	Medicine
Kok Ian don	*Eurycoma harmandina*	Roots	Medicine
Dok khaen (Tiger grass)	*Thysanolaena maxima*	Flowers	Fiber
mai sang phai (Type of bamboo)	*Dendrocalamus lonoifimbriatus*	Stem	Fiber Food
Por saa (Paper mulberry)	*Broussonetia papyrifera*	Bark	Fiber
Kedsana (Aquilaria)	*Aquilaria crassna*	Wood drilled by insects will be-come fragrant	Perfume extract
Faek horm (Vetiver grass)	*Vetiveria zizanioides*	Roots (oil)	Extract
Mark yao (Jatropha)	*Jatropha curcas*	Seeds	Extracted for bio-diesel

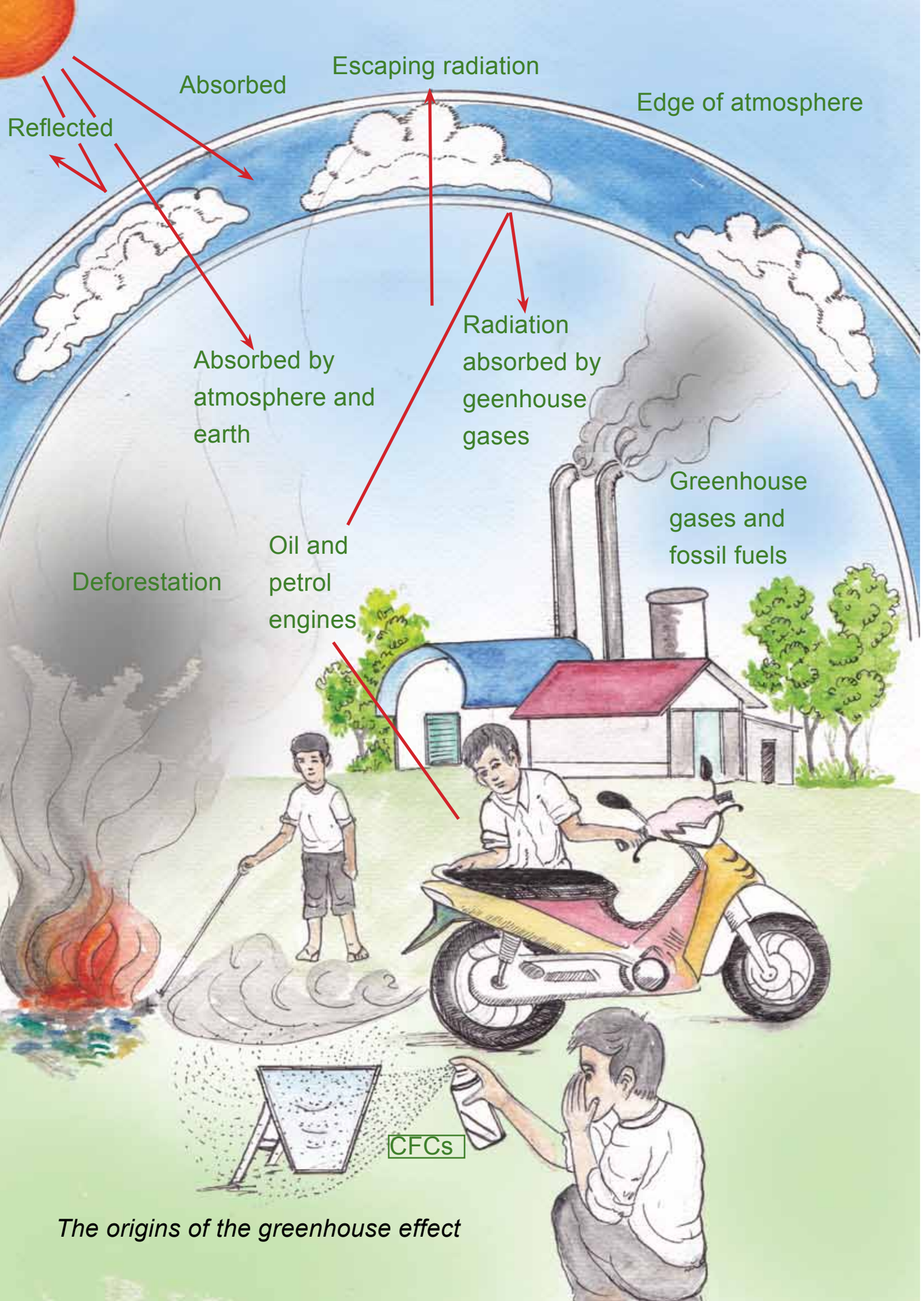
Table4: Examples of non-timber forest products that the population uses for consumption and to create income.

2. Pollution issues for the environment

Definition of environmental pollution: environmental pollution occurs when pollutants exceed the limit that nature and the environment can handle, and will have an impact on the quality of life of humans, plants, animals and the environment.

— The causes of environmental pollution: environmental pollution comes from human sources. Humans have been developing in many sectors without considering the environmental issues that could occur as a result and cause impacts on human hygiene and physical and mental health. The root cause of environmental pollution is the increase in population, because humans are living organisms which have the biggest role in the ecosystem, especially as consumers high on the food chain. Humans use more energy, nutrients and natural resources than any other living organisms in the world. As human population increases, pressure on natural resources also increases, until many of these resources disappear without possibility of renewal. Natural fuels and living resources will disappear.In addition, the use of these resources by humans causes waste and pollution issues.

— Climate change: Climate change is the main environmental issue causing impacts in every corner of the world. Primarily it will have impacts on the global ecosystem: the stability of the world, especially living organisms, the food cycle, water sources, climate, and energy. Climate change will cause unseasonal rains. There will be hot or cold weather at unusual times and natural disasters that never occurred before. These events create serious impacts on the socio-economic system, especially decreased agricultural production. New diseases may also appear.In order to solve these issues, we have to look at their origins at national, regional and global levels, and have sufficient funds to do research and find both the causes and the solutions, and then create and enforce international regulations.



The origins of the greenhouse effect

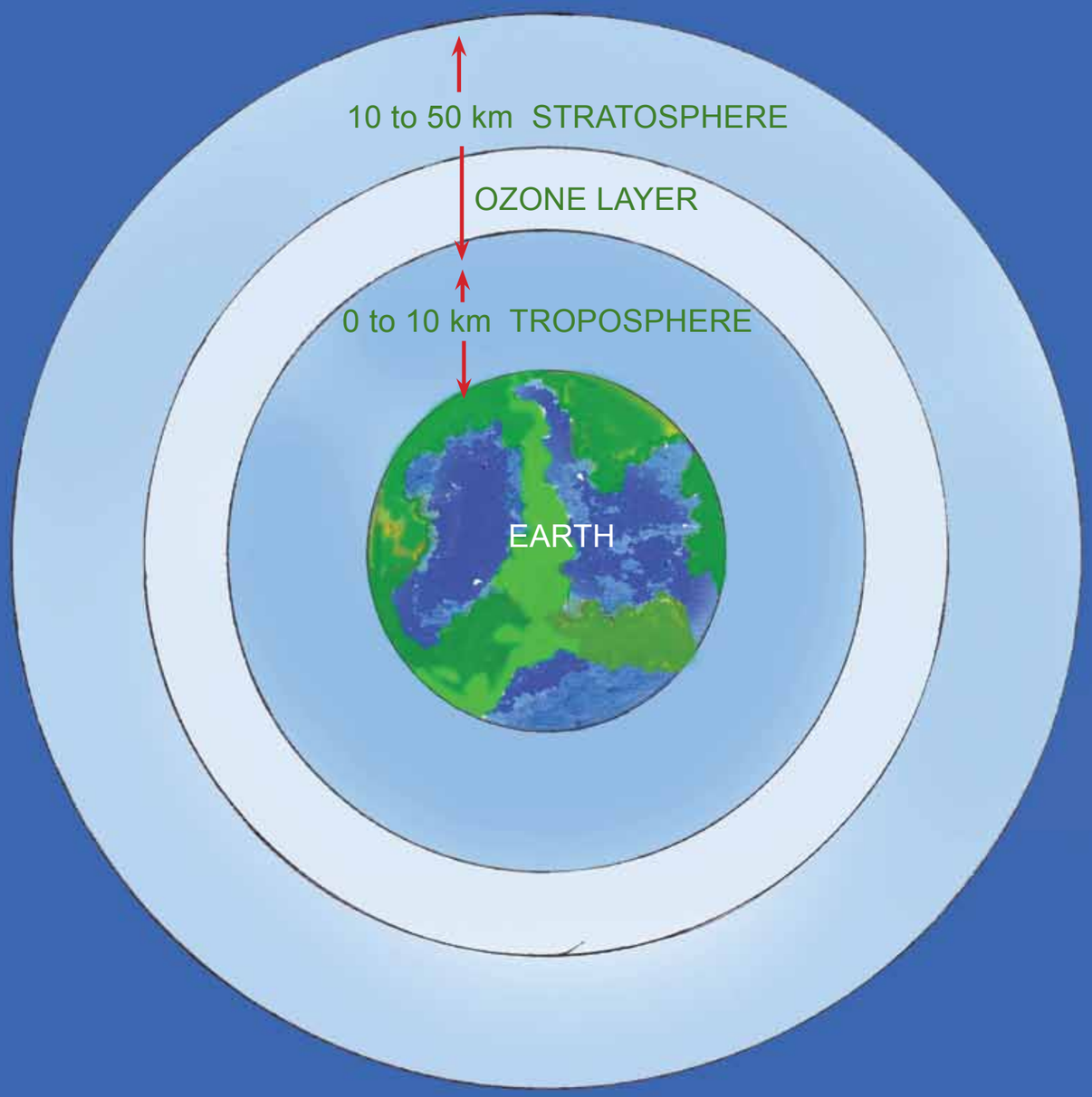
- **The Greenhouse Effect**

What is the greenhouse effect and how did it happen?

Normally, the atmospheric layer of the earth consists of ozone, water, water vapor and other types of gases. Of these gases, ozone will act as a filter to trap UV shortwaves and longwaves radiating towards the earth's surface. This means that the heat radiating the earth's surface has been partially inhibited. This allows the earth to maintain an appropriate temperature for all living organisms. But today humans are changing the earth's temperature through construction and by using chemicals for various activities. This can destroy the earth's protective layer, which will be thicker and unable to evacuate heat properly. This causes an increase in the temperature of the earth's surface and the atmospheric layer. Now there are some gases in too great a quantity in the atmospheric layer of the earth and more than the natural balance requires, which is due to human actions such as the release of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbon (CFC).These gases are capable of absorbing longwave infrared radiation, so when the earth's surface releases infrared rays up to the atmospheric layer those gases will absorb the infrared radiation, which will result in more heat on the earth's surface and in the atmospheric layer. The earth's surface then has a higher temperature. The gases causing such reactions are called "greenhouse gases".

Sources of greenhouse types of gases:

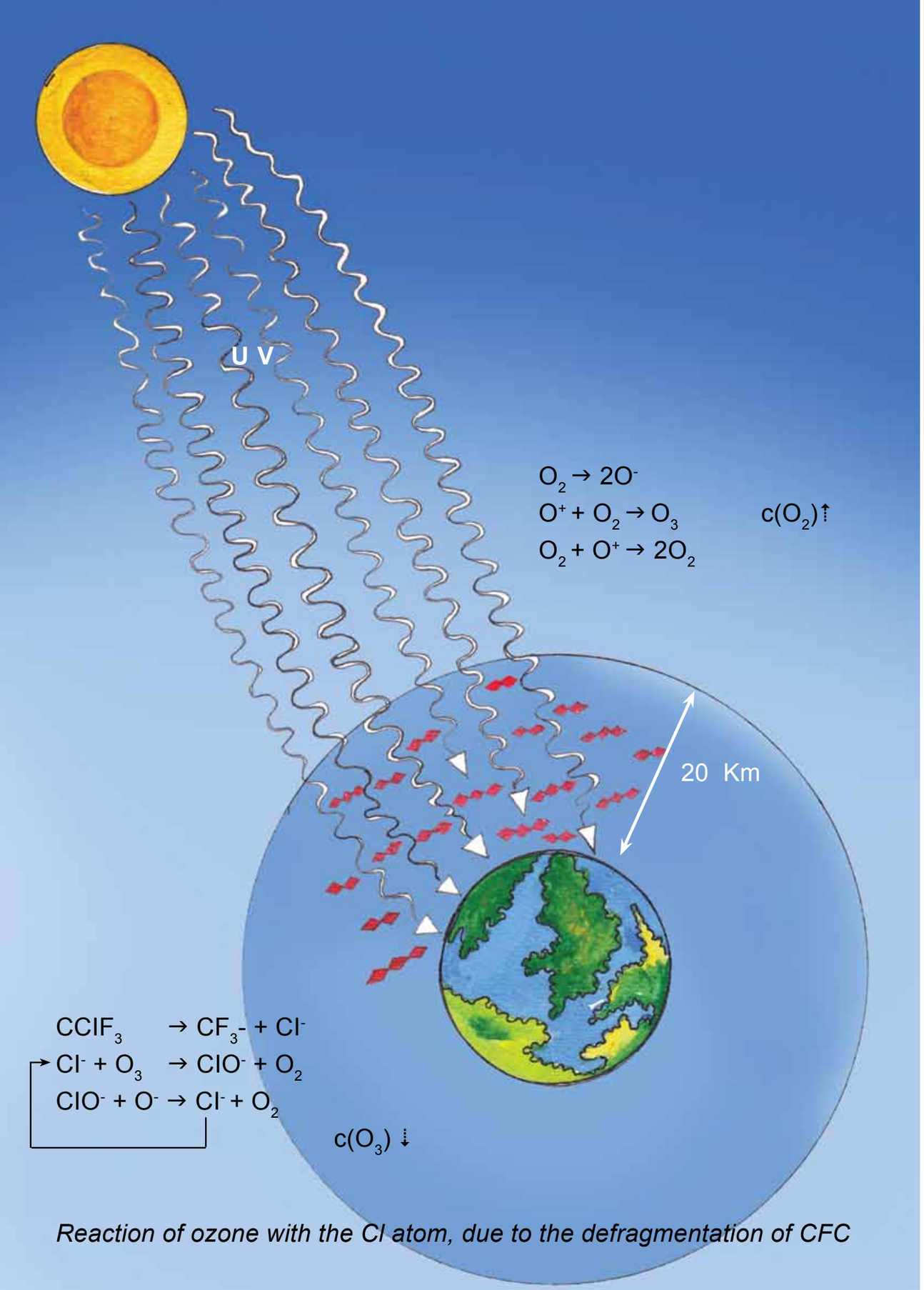
+ Most carbon dioxide comes from the burning of waste and various types of fossil fuels.
+ Water vapor, which is created in the atmosphere naturally.
+ Ozone (or O_3), which is created in the atmosphere naturally.
+ Methane is created by the decomposition of living organisms and in areas flooded for a long time, such as rice fields.
+ Nitrous oxide gas is caused by the decomposition of plants and the use of chemicals; this type of gas can be stabilized in the atmosphere for more than 100 years.



Ozone layer in the atmosphere

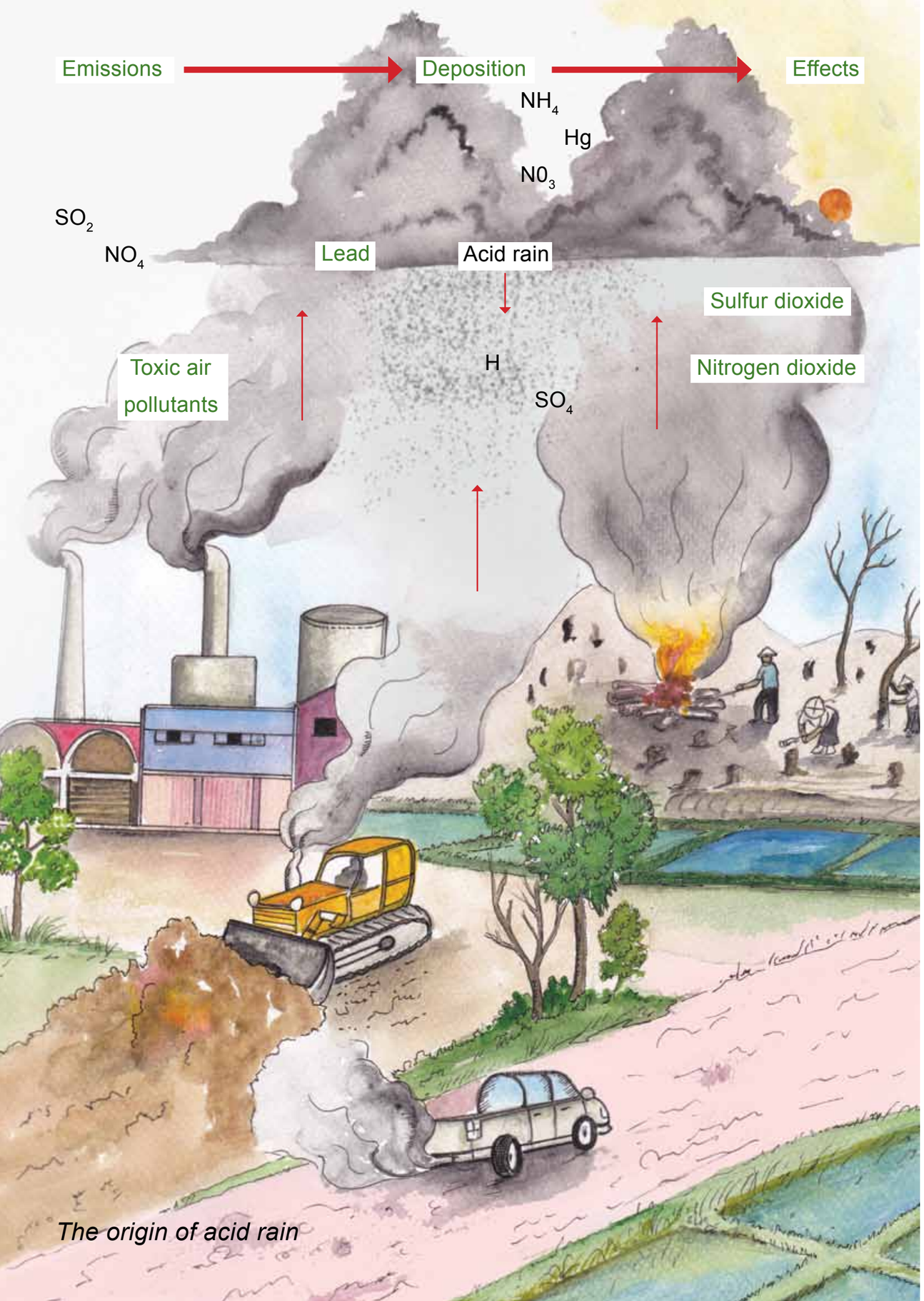
+ Chlorofluoro carbons are created by industrial production and used for the production of cooling equipment, such as airconditioners and refrigerators, and pressurized products such as spray and foam products.

- **Solutions:** To solve these problems efficiently, it is necessary to rely on the cooperation of many actors. Everybody should: preserve natural resources collectively and use natural resources efficiently and in a sustainable manner; stop the destruction and logging of trees; further promote tree planting activities; promote renewable energy; and reduce the use of chemical fertilizers in order to reduce negative impacts on the utilization of soil and the quality of water sources. At the same time, these are also ways to reduce climate change and global warming.Regulations should be followed tightly and people polluting should be prosecuted.
- **The ozone layer:** ozone is one form of unstable oxygen gas, and is very responsive to reactions. Ozone is present in the atmosphere in small quantities, on average 3 out of 10 million air molecules. The ozone in the atmosphere is mostly found in two areas: 90% is found in the lower portion of the stratosphere, from about 10-50 kilometers above Earth. In this area you can find ozone with a thickness of 15-35 kilometers, called the ozone layer. The other 10% is found in the lower layer called the troposphere. This layer is about 10 kilometers high. Although ozone is small in quantity, its role in the atmosphere is very important and useful for the organisms living on the Earth's surface. It protects against ultraviolet (UV) radiation from the sun by filtering it from the Earth's surface. This UV is aninvisible shortwave UV, but harmful to living organisms because it can cause skin cancer. Besides the points mentioned above, ozone is also useful for destroying any type of bacteria and can be used to clean any pollutants. It can solve waste water issues and act as a disinfectant during the drinking water production process.



Reaction of ozone with the Cl atom, due to the defragmentation of CFC

- **The phenomenon of depletion of the ozone layer:** Holes in the ozone layer were discovered for the first time in 1985 and become larger each year when the temperature of the Earth is higher at the lower part of the troposphere. This is caused by the greenhouse effect. At the opposite end, the loss of ozone occurs in the higher layer of the stratosphere, which is the layer protecting Earth from UV radiation which is dangerous for plants, animals and humans. The loss of ozone is caused by a specific gas that humans created, named Chlorofluorocarbon or CFC. This gas is not natural, but man-made for the production of cooling equipment such as airconditioners and refrigerators. In addition to this, it is primarily used as a component for any type of sprays, foams and for plastic production. These gases are most useful but if they are not used properly they will harm the ozone layer. The CFC diffused in the atmosphere, when interacting with UV radiation, will provoke a chemical reaction and liberate the Cl atom. This atom then interacts with an ozone molecule and becomes an oxygen molecule. One Cl atom can destroy ozone molecules thousands of times, as shown in picture. Therefore, the use of CFC is considered to be harmful to the ozone layer as it makes it thicker day by day. This will make humans and numerous other living organisms face more risks of contracting canceras well as other diseases.



The origin of acid rain

3. Acid Rain

Acid rain is a natural phenomenon due to air pollution. It is mostly caused by electricity generation and general industrial production by humans. Acid rain seriously harms the environment. Acid rain is caused by sulfur dioxide (SO2) and nitrogen oxide (NO). These two types of gases are mostly caused by the combustion of various fuels, such as: coal, natural gas and fuel. The two gases, when interacting with water, will provoke a chemical reaction and create some toxins in the atmospheric layers, such as sulfuric acid (H2SO4), nitric acid (HNO3) and other pollutants. These gases will be dispersed for many hundred kilometers and brought back to Earth by rain, snow, fog or rain dust. Damage caused by acid rain has occurred all over North America, Europe, Japan, China and Southeast Asia. Acid rain will dissolve compost in the soil and slow down the growth of crops; when reaching water sources, it will harm the life of living organisms. In cities, acid rain will affect different constructions. If the acid rain fuses with fog, it will create a vapor dangerous for the respiratory system,which might be fatal if the volume is too high. The process of acid rain starts with the burning of various wastes. The burning creates a chemical reaction where the oxygen in the air will fuse with carbon, nitrogen, sulfur and other flammable substances. The substance resulting from that reaction is called anoxide (OX, O3). If there are nitrogen or sulfur components in the fuel burned, it can create oxides. In the USA, 70% of sulfur dioxide comes from power plants, especially in those places where coal is used as a fuel. In Canada there are some industrial activities, such as fuel refining and metal smelting,which will create sulfur dioxide in the atmosphere in concentrations as high as 61%. Nitrogen oxide will come from many sources because most organic compounds contain nitrogen.

- Impacts of acid rain: Acid rain will provoke a chemical reaction in some equipment.pH value will be used as the unit of measurement of value of these acid compounds, with a value between 0 and 14. To become acid, a compound will have a pH between 1 and 6, and the lower the value of the pH, the higher the acidity. At the opposite end, compounds which have a pH between 8 and 14 will be called bases or alkalis. In pure water with a pH7, there is no acidity and the base is called medium. In general, if rain, snow or fog have a pH lower than 5.6, it is considered that that rain, snow or fog is acid. Whenever there is an interaction between the base and the acid, it will reduce the acidity. Normally rain in the atmosphere will be slightly acid and will provoke a reaction with other bases in nature. This will balance out, but whenever the quantity of acid in the atmosphere increases, this will disturb the balance and cause various damages to the environment: to land, to water, to plants and different animals, and to man-made constructions.
- Solutions to and prevention from acid rain

The most efficient way to reduce the issues caused by acid rain is by decreasing the quantity of sulfur dioxide and nitrogen oxide penetrating the atmosphere.This means we should decrease the release of chemicals such as sulfur dioxide and nitrogen from power plants, from car factories and from industrial factories in general. The easiest method is to use economical fuels and effective electrical equipment and make energy savings in general. Following are some examples of solutions found by some countries to the acid rain issue. Many countries use public transportation. In Norway and Sweden, limestone is added to water sources and water tanks to protect water from the damage that acid could cause. In addition, the use of paint or other components to paint buildings can also protect them from acid rain.

4. Noise pollution

Noise pollution occurs when noise is overly loud or when the noise is continuous and causes inconvenience or harm to the auditory system of humans and animals. Noise pollution is one of the environmental issues in big cities, and occurs simultaneously with changes in science, technology, culture and economic growth: noise from cars, planes, any transportation means using engines, noise from engines, from construction, or any audio equipment such astelevision, radio and communications equipment (e.g., noise from cell phones).

Impacts from noise pollution

+ On hearing: sudden noise-induced hearing loss, temporary tinnitus and definitive tinnitus
+ On health: hypertension, palpitations, fast heartbeats, circulatory problems and heart disease
+ On psychological health: sleep disturbances, stress which can lead to depression and psychological disorders
+ On society: it can be an obstacle to building good human relationships, and absence of peace
+ On the environment: impacts on animals such as animals becoming scared and migrating.

Prevention of and solutions to noise pollution

+ Define criteria for the control of each type of noise level
+ Control the noise level at its origin, to keep it at a standard level defined by the law
+ For those living in a noisy area, it is advised to wear protection against noise such as ear plugs
+ The zones where there could be excessive noise should be far from places where silence is needed, such as houses, schools, hospitals and temples, or noise protection should be built in order to decrease the volume of noise.
+ There should be strict measures to reduce the impacts of construction activities.

Chapter III: The Preservation of Natural Resources and the Environment

I. The preservation of natural resources and environment:

To preserve natural resources and environment, we should use natural resources and the environment in a smart way, by using small quantities with the most efficiency and by giving consideration to the duration of the utilization (as long as possible), thus causing less impacts on the environment.

Nowadays, natural resources and the environment are more and more degraded. Therefore, the preservation of natural resources and the environment includes the development of the quality of the environment as well. The preservation of natural resources and the environment can be done in many ways, both directly and indirectly, such as:

1. Direct preservation of natural resources and the environment: actions that can be taken at the individual, organizational and national levels

1) Saving: only use resources based on our needs so that there will be resources available in the long run, and make them of the greatest utility.

2) Recycling: some products used once can be recycled, such as plastic bags and paper, or can be re-used through different processes. For example: used paper can be processed and recycled as cardboard, which will reduce the quantity of natural resources used and reduce the destruction of the environment.

3) The renovation and repair of some equipment: when we use equipment for a long period it can get broken. If we repair it that will extend its life span. This will make us use equipment with the greatest utility.

4) Treatmentand revival: one way to help reduce the degradation of resources is by treatment, such as waste water treatment in households or industrial factories before releasing the water into water sources. For the revival of nature, tree planting is necessary to re-establish the balance of forest fertility.

5) Replacing harmful products with environmentally friendly alternatives is one of the ways to decrease the use of natural resources and to avoid causing harm to the environment. For example, use fabric bags instead of plastic bags, use banana leaves instead of foam boxes, use solar energy instead of fossil fuel and use organic fertilizers instead of chemical fertilizers.

6) Oversight and prevention is one of the ways to protect natural resources and the environment from destruction, such as:overseeing when rubbish is thrown into rivers, or building structrures to prevent forest fires.

2. Indirect preservation of natural resources and the environment in many ways:

1) Improve the quality of the population by: supporting actions to promote environmental education; the preservation of natural resources and the environment in schools or institutions; disseminating information for informal education; making the population see the importance and the necessity of preservation, having a concern for it and providing real cooperation.

2) The use of legal and social standards: set up community groups such as WCS, WWF and others for the preservation of natural resources and the environment and provide physical and mental co-operation by showing awareness of the value of the environment and the resources we possess.

3) Encourage the local population to be involved in preservation: preserve the environment together how it was and not degradate it. For the livelihood of the local population we should create knowledge, understanding and awareness between local authorities and the population. Delegate roles and duties in terms of preservation and revival of the resources most commonly used.

4) Promote studies and analysis of methods and develop the most useful technologies to manage natural resources and the environment such as: use information and technology knowledge to plan for the development of material and equipment to make more energy savings; research and analysis of management methods for the improvement of a qualitative and sustainable environment.

5) Define policies and directions of the government in terms of preservation and improvement of the environment in both the short and long term, for individuals, organizations and government officials to put into practice, and disseminate information on the preservation of natural resources and the environment directly and indirectly.

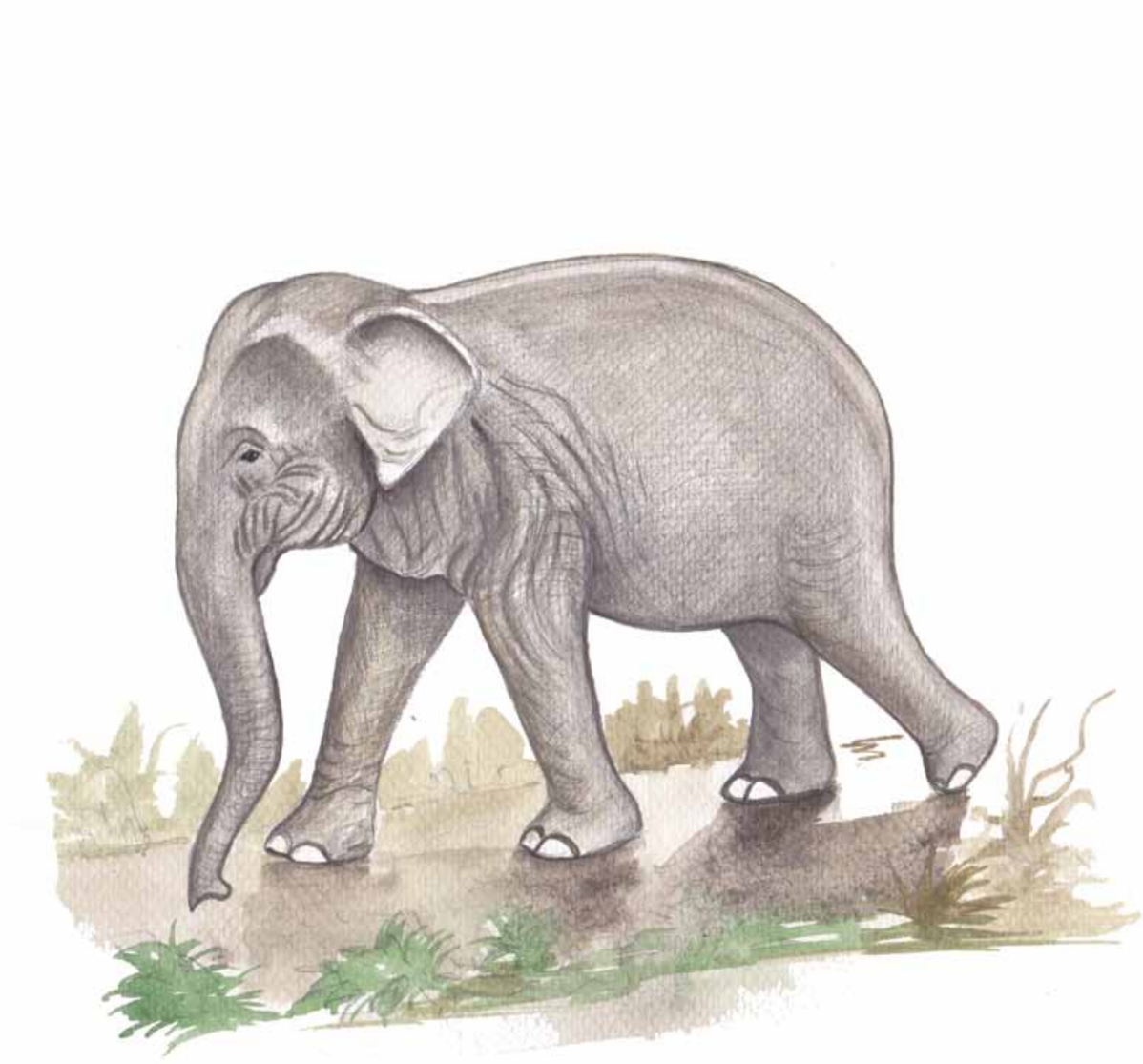
Conventions and international agreements for the management and protection of the environment

Lao PDR has had the opportunity to participate in several sharing and consultation conventions about environmental issues at the international level. Environment-related topics have been included in the National Socio-Economic Development Plan and plans, programs and projects have been developed accordingly. The Conventions about the environment that Lao PDR participated in, include:

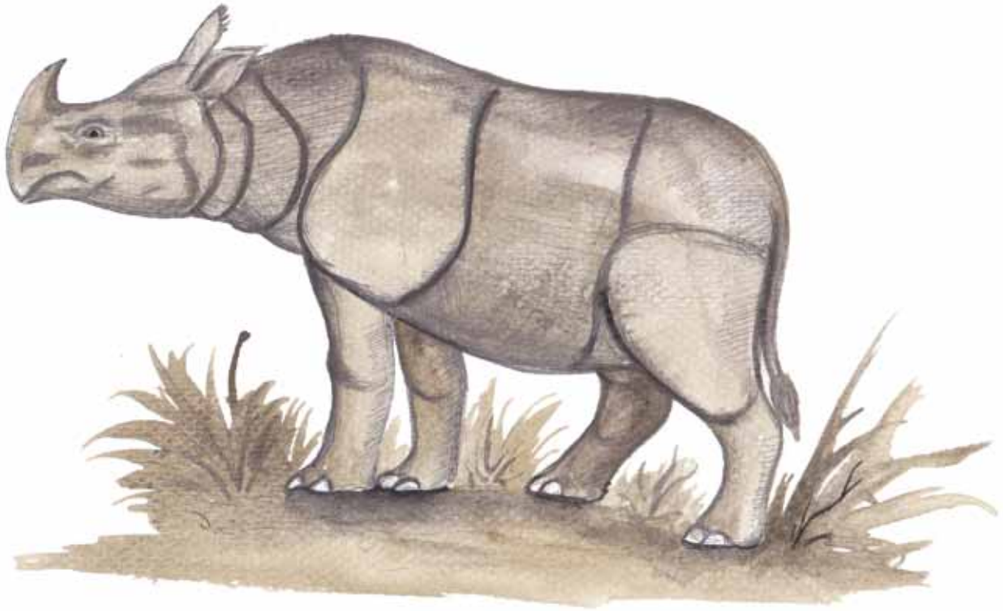
+ The Climate Change Convention, organized in Rio de Janeiro, Brazil, in 1992
+ Convention to combat desertification and droughts, organized in Rio de Janeiro, Brazil, 1992
+ Convention on biological diversity organized in Rio de Janeiro, Brazil, in 1992
+ Convention on World cultural and natural heritage, organized in Stockholm, Sweden, in 1972
+ Vienna Convention for the protection of the ozone layer, organized in Austria, in 1985
+ Treaty on Persistent Organic Pollutants, organized in Stockholm, Sweden, in 2001
+ Kyoto Protocol, organized in Tehran, Iran, 2003
+ Convention on International Trade in Endangered Species of Wild Fauna and Flora, organized in the USA, in 1973 or Convention of Washington. The Lao PDR has also participated in this convention as one of the parties since May 30th 2004. The objective of this Convention is to regulate the trade of wild animals and flora in danger of extinction between countries, and to avoid harm to the survival of wild animals and flora.

	List I - Examples
Hylobates spp	*All types of gibbons*
Pygathrix nemaus	*Red-shanked douc langur*
Elephas maximus	*Asian elephant*
Panthera tigris	*Tiger*
Capricornis sumatraensis	*Sumatran serow*
Rhinoceros sondaicus	*One-horned Rhinoceros*
Ursus thibetanus	*Asian black bear*
Varanus bengalensis	*Bengal monitor*
Paphiopedilum spp	*All types of slipper orchids*
	List II - Examples
Manis spp	*All types of pangolins*
Naja naja	*Cobra*
Ophiophagus hannah	*King cobra*
Cuora ambolensis	*Amboina Box turtle*
Dendrobium spp	*All types of orchids*
Aquilaria spp	*All types of aquilaria trees*
Python reticulatus	*Asiatic reticulated python*
	List III - Examples
Odobenus rosmarus	*Walrus*
Bubalus arnee	*Wild water buffalo (domestic buffaloes not included)*
Viverricula indica	*Small indian civet*
Sacalia quadriocellata	*Four-eyed turtle*
Ocadia sinensis	*Chinese striped neck turtle*
Naja atra	*Chinese cobra*

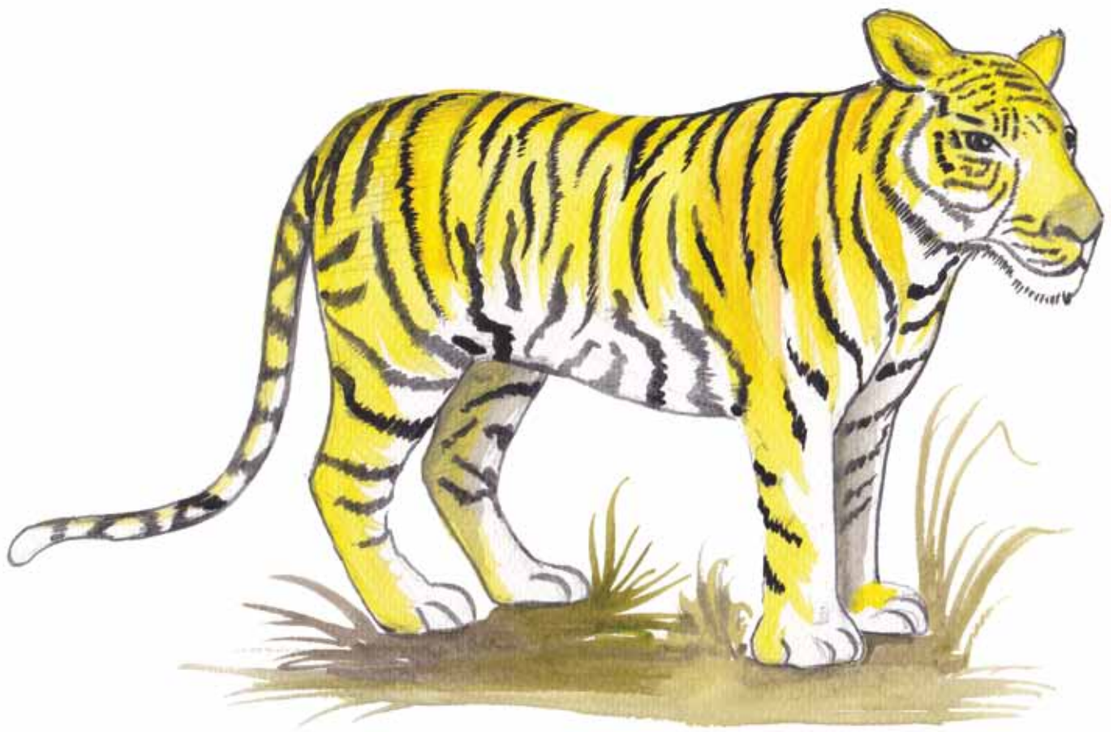
In addition to the ratified conventions mentioned above, the Lao PDR has also participated in some environmental events in the region: the Lao PDR is a member of the MRC and ASEAN, and has been actively involved in consultations and maintains bilateral cooperation with its neighboring countries: China, Vietnam, Cambodia and Thailand.



Asian Elephant (Elephas maximus)



One-horned Rhinoceros (Rhinoceros sondaicus)



Tiger (Panthera tigris)

Slipper orchids almost in extinction (Paphiopedilum spp.)

Pha Tad Ke Botanical Garden, Luang Prabang, Lao PDR

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Drawings & Graphic Design: Kongngern Sengdee

www.pha-tad-ke.com

ຄວາມສະຫລາດເປັນເລື່ອງຂອງສະໝອງ ບໍ່ແມ່ນບຸກຂະລິກໜ້າຕາ.

ຖ້າໂລກນີ້ບໍ່ມີສິ່ງທີ່ເອີ້ນວ່າ: ຄວາມອິດທົນ ເສຍແລ້ວ
ບໍ່ວ່າຈະຢູ່ແຫ່ງຫົນໃດ ກໍບໍ່ສາມາດບັນລຸຄວາມສຳເລັດອັນຍິ່ງໃຫຍ່ໄດ້.

ຂ້ອຍຍ່າງຊ້າ
ແຕ່ຂ້ອຍບໍ່ເຄີຍຍ່າງຖອຍຫຼັງ.

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ເຮືອຈະແລ່ນໄປທາງຊ້າຍ ຫຼື ຂວາ
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Pha Tad Ke Botanical Garden

ສວນພຶກສາຊາດ ຜາຕັດແກ້ ຕັ້ງຢູ່ແຄມແມ່ນ້ຳຂອງ ທີ່ຫຼວງພະບາງ ເປັນສວນ
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ຜູກພັນມາແຕ່ຊ້ານນານ ມາປູກ ແລະ ປົກປັກຮັກສາໄວ້ໃຫ້ຄົນລຸ້ນຫຼັງໄດ້ເຫັນ
ແລະ ສຶກສາ ຄຽງຂ້າງກັບການປູກພັນພືດທີ່ມາຈາກແຫ່ງອື່ນ ເພື່ອເປັນການສ້າງສິ່ງ
ເອື້ອອຳນວຍໃຫ້ແກ່ການຄົ້ນຄວ້າວິທະຍາສາດ, ອັນຈະເປັນສ່ວນປະກອບໃນການ
ສຶກສາ ພຶກສາຊາດຂອງປະເທດລາວ ແລະ ຊີວະນານາພັນຂອງໂລກອີກດ້ວຍ.

ໂລກນີ້ຄືໜັງສືຫຼາຍເຫຼັ້ມ
ຖ້າຢູ່ແຕ່ໃນບ້ານ ກໍເທົ່າກັບວ່າ
ໄດ້ອ່ານໜັງສືນ້ອຍພຽງເຫຼັ້ມດຽວເທົ່ານັ້ນ.

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