永續農業的生產力與持續性：幫助人類面對環境、經濟與社會問題

Productivity and sustainability of Permaculture: Helping populations to cope with their environmental, economic and social issues

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Abstract

Although Permaculture has been successfully implemented and used various times over the past 40 years, too little is known about this notion and about how it can offer to humanity the solutions of tomorrow to cope with the current world situation. Throughout their books, articles and trainings, most authors and experts – such as Bill Mollison, David Holmgren or Toby Hemenway - used the same systematic and scientific approach to expose the major problems of the world. The same authors also tackled the solutions of these problems in the same way: what are the environmental and social problems that the world is currently facing, and how can Permaculture deal with them on a global scale. However, the latter lacks in implementing what is called a daily life oriented approach to the same topic, that is to say reflecting upon a profitable and sustainable way of dealing with the problems mentioned above that directly impact our daily life. This approach, which involves the concepts of livelihood, health and close environment, is better visualized by the majority of the population who can explore the various concepts of Permaculture via a different angle and get a clearer understanding of how Permaculture works and how it can help them in their daily life. Thus, this dissertation aims to determine whether Permaculture can be an answer to the main socio-environmental challenges that are poverty alleviation and sustainable development by examining the benefits of Permaculture in terms of productivity and sustainability. Productivity to ascertain whether Permaculture is able to support households’ daily life, and sustainability to ascertain whether Permaculture designed systems are meant to indefinitely last and be regenerative instead of degenerative for the environment. This thesis gathers, confronts and further develops the existing knowledge around Permaculture in order to encourage and guide people in adopting Permaculture ethics, principles and methods to ensure a better economic and ecologic environment for themselves and a sustainable future for their children.
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Chapter 1: Introduction

1.1 Background of research

1.1.1 Current world socio-environmental challenges

Our planet is in danger. Needless to be a scientist to understand that given the frantic rhythm
of development and consumption people have been living with during the past decades, or
even centuries, our planet is heading for ruin. If a diagnosis of the current world situation was
to be made, this would paint a bleak picture of the future. Pollution of air, water and soil;
climate change due to greenhouse gazes emission leading to global warming; overpopulation
of the planet, with a population facing shortage of basic resources that are essential for
survival; destruction of ecosystems leading the extinction of species and the loss of
biodiversity; deforestation for residential, commercial or industrial purposes; urban sprawl
due to the migration of population from high density urban areas to low density rural areas
which results in spreading of city over more and more rural land resulting in land degradation
and other environmental issues; health issues for humans and animals as a consequence of
environmental problems on one hand, but also coming from the genetic modification of food
or the pollutants applied to increase the productivity of farms. According to Rinkesh, (2009),
these are the major environmental issues that humanity is currently facing.

Besides these environmental issues, for which most people have not realized the major
importance that they represent because they do not impact them directly, lies an even bigger
concern: the issue of the basic dietary needs of the ever-growing population. Even without
taking into consideration the developing countries such as African countries or South-East
Asian countries, where most people are constantly struggling to fulfill their basics needs in
order to survive, this also applies to developed countries where there is still a big part of the
population, covered by debts, taxes and with unpaid or underpaid jobs. It is true that since
1990, many poor people have been able to get out of poverty (poverty rates decreased by
more than half). Despite that, though having a job, too many people remain poor across the
world (International Labour Organization, 2016). Indeed, nowadays almost one third of the poor in emerging and developing countries actually do have a job. However, these jobs are far from being a guarantee of safety: they are sometimes unpaid or underpaid, concentrated in low-skilled occupations and do not have any social protection (International Labour Organization, 2016). Therefore, each country in the world has its own amount of poor people who have hard time buying or finding food to feed their families.

Moreover, the world is currently facing a major food crisis. By the year 2050, the UN DESA (United Nations Department of Economic and Social Affairs) report, “World Population Prospects: The 2015 Revision” forecasted that the population will reach 9.7 billion. Thus the following problem: how is it possible to feed 9 billions of people while the Earth is not able to feed 7 billions today? Olivier (2012) found that in many developed countries, the dietary needs account for about 10 to 12% of the household budget. In developing countries, it is naturally more. For example, Egypt food costs are about 40% of the household budget. In India, over 40% of the children under the age of 3 are undernourished and underweight. In Greece and Spain, hit hard by the financial crisis first then austerity measures that came along with the crisis, many people regularly found their food in garbage bins. Therefore, the conclusion is that humanity is currently in the middle of a major food crisis that is not going to be solved any time soon. In addition, global grain prices have almost tripled from 2002 to 2012, and have then come back to a similar level (similar to 2002 but still higher) in 2016-2017 (World Bank, 2017). The volatility of the grain prices is unpredictable and thus dangerous. If grain prices were to double within the next 20 years, hundreds of millions of people worldwide would be left to starvation. Water is not an unlimited resource and is getting scarce. According to Olivier (2012), about 300 million people in China and India depend on aquifers that will soon dry up. The Ogallala aquifer in America, which covers parts of eight states, is predicted to dry up in 20 years (Olivier 2012). Similarly, aquifers under the capitals of China, India and Thailand Beijing, Delhi, Bangkok as well as many other major Asian cities are drying up as well. Major rivers such as the Ganges, Jordon, Nile and Yangtze, at certain times of the year, are considerably reduced. Water is not only used in our daily life as a beverage, but also in numerous farmlands throughout the world that will be facing a critical shortage. Finally, Olivier (2012) found that more and more people in developing
countries demand higher quantities of meat in their daily diets. But the meat production is far from efficient. In developed countries, it takes 2,500 gallons of water, 12 pounds of grain, 35 pounds of topsoil and the energy equivalent of one gallon of gasoline to produce one pound of feedlot beef (earthsave.org). Due to a failure during the past ten years in increasing the productivity of grain production in Asia and Europe, it will be obviously be difficult, even impossible, to produce even more grain to feed animals in the developing countries (Olivier, 2012).

1.1.2 Conventional Agriculture: solution or cause?

Eckard (2015), Associate Professor in the University of Melbourne’s Faculty of Veterinary and Agricultural Science, explains the challenge of increasing food production to feed the world while turning conventional Agriculture into sustainable Agriculture. As stated above, the global population is predicted to reach around 9 billions by 2050. In parallel, to meet this future need, Agriculture will have to increase production by at least between 60 and 80% by 2050. Meanwhile, due to a slow down in investment in agricultural research and development, as well as a stabilization of Agriculture expansion into new areas, the world is currently witnessing a constant decline in agricultural productivity and resources. Furthermore, available farmlands are reducing, and even the remaining lands have to deal with some form of degradation mainly due to erosion, soil acidity and soil salinity. According to the UN Environment Program (2006), 25% of the world’s food production will likely be lost because of environmental degradation by 2050.

According to Eckard (2015), to meet the challenges mentioned just above, more food needs to be produced while using less lands, inputs (e.g. water) and energy, and while reducing soil breakdown and greenhouse gas emissions. In other words, the huge impact intensive Agriculture has on the environment has to be taken into account and restrained as much as possible and restrain it as much as possible. Aside from reducing food wastage, which could and should be an action to take, a new pattern called “sustainable intensification” has emerged in Agriculture, aiming to combine the rise in production along with the restriction of environmental footprint coming from food production.
However, although research over the past 60 years has considerably increased production, it
does not seem to be the case any longer, because nutrient inputs, fertilizers and water inputs
have led to diminishing returns. More inputs alone will no longer improve the efficiency or
sustainability.

Thus, to some experts, the term sustainable intensification is an oxymoron, as most
agricultural intensification cannot come without a negative pressure, and further degrade the
available natural resources, making the intensification harder.

In order to explain to what extend Agriculture is by nature unsustainable and cannot be
sustainable, Hemenway (2011) came back to the origins or Agriculture, when it emerged
10,000 years ago. Starting from that point, he drew up a comparison between farmers, who
grow their own food in farms (agricultural method) and foragers, who look for their food in
nature (hunter-gatherer method) over the years. Below are the characteristics he found out:

Table 1: Comparison between farmers and foragers

<table>
<thead>
<tr>
<th>Farmers</th>
<th>Foragers</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Worship gods whose message usually is that humans are chosen beings holding dominion. Therefore, not only ecological degradation is inevitable but is also sign of progress</td>
<td>- Orbit most fundamentally around food, which defines their culture</td>
</tr>
<tr>
<td>- Calories mostly come from grains</td>
<td>- Calories mostly come from meat, fish, fruits, nuts</td>
</tr>
<tr>
<td>- Storable food, surplus, calories from carbohydrates (grain are more calorie-dense than forager food): sedentary, with growing population (more calories means more births)</td>
<td>- Live in small bands and tribes, with a low and stable population</td>
</tr>
</tbody>
</table>
- Agriculture’s surplus requires hierarchy: someone to distribute, someone to guard, someone to produce, etc.

- Slow feedback from degrading the environment. Degrading the environment brings more food, so they keep doing it

- Loss of biodiversity means more food: have to clear forests to grow crops

- Wilderness is a nuisance, a source of pest animals and insects, as well as land that’s just “going to waste.”

- A growing population needs more food, and crops can be grown everywhere: nurtured the Agriculture expansion. Farmers are conquerors

- Farmers need 2-3 days to gather a week’s food, plus more to pay facilities

- Not healthy overall (malnutrition, diseases, lifespan of 19 years old, diseases, epidemics due to domesticated animals, etc.)

- Frequent famine. E.g. France suffered country-wide famines 10 times in the tenth century, 26 in the eleventh, 2 in the twelfth, 4 in the fourteenth, 7 in the fifteenth, 13 in the

- Flat hierarchy, people have no exclusive skills, everyone helps gather food

- Do not overexploit their environment as destruction of resource one season can lead to starvation the next season. Fast feedback

- Loss of biodiversity means no food

- Wilderness is necessary, the plants and animals they depend on cannot be over-harvested without immediate harm

- Seldom conquer new lands, as new terrain and its different species would alter the culture’s knowledge, stories, and traditions

- Foragers need 3 hours to gather a week’s food

- Healthier (lifespan of 26 years old)

- Less frequent famine: much more diverse food supply and greater mobility. Can find food in nearly any conditions
sixteenth, 11 in the seventeenth, and 16 in the eighteenth century

- Agriculture became a reliable source of food when fuels gave farmers the necessary energy to supply their work
- Do not only require lands to farm but also various inputs (fertilizer, fuel, tools, etc.)
- Nowadays expend 10 to 15 calories to harvest 1 calorie of food energy

- Forage culture does not need any fuel to work
- Only require what nature provides
- Expend 1 calorie of energy to harvest 40 calories of food

Note: reproduced and adapted from *Is Sustainable Agriculture an Oxymoron?* Hemenway (2011)

This comparison helps to better understand why Agriculture is fundamentally unsustainable and cannot be sustainable. A process that fears wildness (fear of bugs, fear of wild animals that would tear down fences, fear of deers that eat the crops, etc.) to the point that it needs to destroy it to exist (destruction of forests to get access to a land). Furthermore, Agriculture uses much more inputs than outputs it can generate (calorie-wise), and cannot do otherwise. What if the harm of Agriculture could be controlled? What if humanity intended to make Agriculture more sustainable? Hemenway (2011) thinks this would not change the outcome. According to him, laws could be passed in order to stop some of the harm Agriculture does, but these rules would reduce harvests. As soon as food gets scarce, the laws will be canceled. There are no structural constraints on Agriculture’s ecologically damaging tendencies.

Tittonell (2013), former chair Professor of the group Farming Systems Ecology of Wageningen University (Netherlands), answers the question of affordability of agricultural production and its possibility to feed the planet. In his opinion, people must stop asking themselves the rhetorical question: can conventional Agriculture feed the world? The
successive reports on security food co-published by UN Food and Agriculture Organization (FAO), the World Food Program (WFP) and the International Fund for Agricultural Development (IFAD) every year, stating that “about 795 million people are undernourished globally, down 167 million over the last decade, and 216 million less than in 1990–92” (The State of Food Insecurity in the World, 2015). In addition, it is common knowledge that the world produces way more food than enough to feed the planet (more than 1 ½ times). Therefore instead, based on these numbers, the world must acknowledge that conventional Agriculture has failed to feed the world mainly due to two reasons: worldwide, food is not produced where it is mostly consumed or needed; and energy, chemical and genetic inputs used in conventional Agriculture are not affordable for all farmers. Currently, about half of the food produced worldwide comes from small farmers. Besides, of the total energy contained in one grain of maize produced in high input Agriculture about 70% comes from fossil fuels. More than 30% of this energy is used in the manufacture of chemical fertilizers. And yet, these small farmers mentioned above cannot afford such costs. In fact, in developed countries, Governments subsidize conventional Agriculture so farmers can afford fertilizers and fuel for their mechanics. Afterwards, the taxpayer’s money will then again pay for the depollution of grounds depleted beforehand by the use of these fertilizers. Some farmers even contract debts in order to intensify their production, and often go bankrupt, as they are unable to repay them. It is a vicious circle, originally generated by the very essence of Agriculture. This vicious circle has various aftermaths on society on different levels: for households, food is often too expensive. For farmers, they are not profitable enough and are struggling for life.

Hemenway (2011) goes beyond and even states that Agriculture is the cause of a social and political problem. According to him, the goal of Agriculture, which was developed at a time when civilizations needed more food to sustain their activities and to feed the growing population, is to generate surplus. Inevitably, this surplus nurtured a hierarchy so as to store it, protect it and decide who would be allowed to use it. At the same time, needless to say that any kind of surplus is doomed to be lusted after by neighbor, thus leading to wars. This system has concentrated power into the very few people who control the surplus, and has severed the personal freedom of the rest of the population.
1.1.3 Hypothesis: Permaculture as an alternative?

After understanding the failure of Agriculture to take up the challenge of saving our planet’s health and helping people to get out of poverty, another method that is able to accomplish that must be found.

The word Permaculture, coined in the 70’s by the two Australian Mollison and Holmgren (1978), is a contraction of “permanent” and “culture”, initially “permanent” and “Agriculture”. Permaculture claims to be the fastest, easiest and most effective solution to face Humanity and planet issues. It is an ethically based design system for human habitation that is in harmony with the natural world.

The definition Bill Mollison and David Holmgren gave in their book Permaculture one defines Permaculture as “Consciously designed landscapes which mimic the patterns and relationships, found in nature, while yielding an abundance of food, fibre and energy for provision of local needs.”

In other words, Permaculture integrates land, resources, people and the environment through mutually beneficial synergies by imitating the no waste, closed loop systems seen in diverse natural systems. As there is no permanent Agriculture without a culture to support it, Permaculture is also “permanent culture”. Permanent here means something stable and enduring, which can continue indefinitely without change. Hence, lands, resources, environment refer to systems and structures that are designed to sustain. And if they are designed to sustain, that means they are also to offer more energy than they took to make. In other terms, to provide more outputs than the inputs that have been used.

First, Permaculture relies on three ethics (Holmgren, 2002):

- Care for the earth and every kind of life beings (husband soil, forests and water, animals)
- Care for people and build communities (look after self, kin and community)
- Fair share (set limits to consumption and reproduction, and redistribute surplus to the Earth and to people).
Furthermore, Permaculture takes inspiration from three models:
- Wild ecosystems in order to establish and maintain effective, self-sufficient, sustainable, regenerative, resilient, non-polluting, safe and diversified systems (and societies)
- Knowledge and knowhow from the first peoples and sustainable societies
- Latest natural sciences advancements (science of systems, ecology and social economy, renewable energies, botanic, water management, etc.). Not to be confused with technology advancements.

Lastly, Permaculture follows a dozen of principles that slightly differs from an expert to another. Mollison (1988) included a comprehensive list of principles in the *Permaculture Design Manual*. Later on, Holmgren (2002) consolidated and repackaged these principles into twelve in his book *Permaculture: principles & pathways beyond sustainability*. For simplicity sake, the Holmgren’s twelve principles will be presented in this thesis.

**Principle 1: Observe and interact**

Pre-industrial societies with high population and industrial societies respectively depend on large input of manpower and large inputs of fossil fuel energy. At the contrary, Permaculture designers observe carefully and interact thoughtfully to use more effectively human abilities and also reduce dependence on fossil fuels (non-renewable) energy and high technology.

**Principle 2: Catch and store energy**

A huge amount of fossil fuels has already been harvested, and part of this amount has already been used in order to increase the productivity of harvesting the Earth’s renewable resources. But the degree that has been reached by doing so is unsustainable and dangerous. Thus, it is necessary to learn how to save and reinvest in a smart and sustainable way most of the wealth that is currently consuming or wasting, for the sake of the future life of people’s children and descendants’.
Principle 3: Obtain a yield

Following the second principle, energy must be captured and stored so as to maintain the system one implemented. A system, autonomous at all levels, must be designed. Then, the objective is to obtain a yield as a reward that encourages, maintains and/or replicates the system that generated the yield. Only then the system will be successful and will spread. These rewards are called “positive feedback loops” and serve to boost the system.

Principle 4: Apply self-regulation and accept feedback

In order to get a resilient system that can resist to external disturbances, it is important to build this system with self-reliant elements. Moreover, by using the positive and negative feedbacks can be found in nature, more self-regulating systems can be built. Achieving to build self-maintaining and regulating systems can considerably reduce the amount of human labor.

Principle 5: Use and value renewable resources and services

Although some inputs of nonrenewable resources are necessary to get started, Permaculture design aims to mostly use renewable natural resources - resources that can be renewed and replaced over time without any other nonrenewable inputs - to obtain, manage and maintain yields.

Also, Permaculture should nurture the various possibilities of harmonious interactions between humans and nature, to really include as many parts of nature as possible in the process. This is for example the close relationships human always had with domestic animals such as the horse or other animals for transport, soil cultivation, etc.

Principle 6: Produce no waste

It is true that wasting is easy when there is abundance. However, that waste will most likely turn into troubles later. Bill Mollison defined a pollutant as “an output of any system
component that is not being used productively by any other component of the system”. Thanks to this definition, people need to always be looking for ways to reduce waste and pollution by making good use of all outputs. Indeed, with a better use of all the resources that are available, nothing goes to waste. For example, the outputs for one entity can be the inputs for another. This is the case of the earthworm, which converts plant litter (wastes) into humus that improves the soil environment (beneficial for soil, micro-organisms and plants).

**Principle 7: Design from patterns to details**

Given the similarities between patterns that can be found in nature and society, it becomes easier to simply understand and apply them – as the backbone of our designs - in other contexts and scales while implementing a system. Forests initially served as example to design Permaculture. The concepts and patterns found in forests have been and are still a good example for Permaculture, which is still drawing on forest model.

**Principle 8: Integrate rather than segregate**

Integration is central in Permaculture. A functional and self-regulating design placed its elements in such a way that each of them provides the needs and gets its supplies from other elements of the system. A correct placement of all the elements makes possible the development of a higher degree of integration and self-regulation, considerably reducing again manual labor (for corrections).

To do so, two genuinely important statements in Permaculture must be applied:
- Each element of the system serves many functions.
- Each important function is supported by many elements.

**Principle 9: Use small and slow solutions**

Systems should be designed on a small scale with slow functions. In that way, the system will be easier to maintain than big systems, and will provide more sustainable outcomes.
In forestry, fast grown trees often do not live for a long time, whereas some trees grow slower but are more valuable species, offering a better yield. For example, a small plantation of thinned and pruned trees can yield more total value than a large plantation without management. Similarly, naturally raised animals will live longer than concentrated, nutrients fed and rapidly grown animals due to their higher disease disposition.

**Principle 10: Use and value diversity**

Permaculture should leave aside monoculture and foster polyculture instead. Indeed, polyculture is a very good application of diversity in Permaculture and permits the farmer to reduce the vulnerability to pests, danger of seasons and market fluctuation. Other applications of this principle that are also crucial can be found as well, such as the diversity in the different cultivated systems regarding the nature of the site, the location, the context, etc., or the diversity in structures.

**Principle 11: Use edges and value the marginal**

For the sake of system productivity and stability, this principle implies that the emphasis must be put on the edges and the marginal and invisible aspects of the system. Indeed, the interface between two entities, such as a forest and a pasture, or the soil and the atmosphere, is where the most interesting events take place due to the crossover of the two entities. These interfaces - edges - are often the most valuable, diverse and productive elements in the system.

**Principle 12: Creatively use and respond to change**

Two threads respond to this principle:
- Designing to make use of change in a deliberate and cooperative way. By understanding how ecosystems change over time - this is predictable) - the process can be accelerated and productive ecosystems can be created faster than is usual in nature. Forest gardens are an example of this, where all the layers of the forest are put in all in one go, rather than over many years.
- Creatively responding or adapting to large-scale system change that is beyond human’s control or influence (climate change, peak oil, resource depletion, etc.)

Permaculture is most well known for its food systems and forest gardens. The following pictures and schemes show an example of what a farm in Permaculture looks like.

Figure 1: Contemporary/Western Agriculture farm
Note: Reproduced from Introduction to Permaculture, Morison (1991)

Figure 2: Permaculture farm
Note: Reproduced from Introduction to Permaculture, Morison (1991)
Thus, according its definition, Permaculture seems to be an enduring and sustainable method, integrating landscapes, animals, plants and people all together and that is capable of offering more outputs than inputs initially needed by the system to work properly. The question now is to see whether Permaculture can claim to be the alternative solution to face the socio-environmental challenges describes in the first part of this chapter. This will constitute the body of the text of the thesis that will be developed in the following chapters.
1.2 Motivations and Objectives

This thesis is meant to raise the awareness among people about Permaculture and its tremendous power to regenerate the planet of tomorrow. Everyone knows about the challenges that must be overcome in order to give a future to our children and descendants. However, very few people know about the solutions, about how to have a meaningful impact at a small scale, going way further than the simple daily actions such as recycling or avoiding waste as much as possible. Then why is Permaculture so little known? If it is so efficient as the thesis is about to expose in the following development, why is Permaculture not relayed by medias and newspapers, or encouraged by governments and companies? There is no proven fact about this statement, but people among Permaculture agree on the point that there are too many actors belonging to the chain of Agriculture, due to the inherent nature of Agriculture that relies on many inputs and fossil fuels to exist. To quote some of them: the oil industry, the pesticides industry, the fertilizers industry, the pharmaceutical industry (for poultries), etc. These actors all defend their own interests and certainly block any alternative that could save people and the planet. Especially Permaculture, which does almost entirely not rely on any of these industries, and yet can be even more productive than Agriculture on a small scale.

This thesis aims at examining the benefits of Permaculture in terms of productivity and sustainability; productivity to determine whether Permaculture is able to support households’ daily life, and sustainability to determine whether Permaculture designed systems are meant to indefinitely last and be regenerative instead of degenerative for the environment. Then, the thesis will provide the possibilities and opportunities that people have, as individuals or groups of people, to apply Permaculture in their daily life.

Consequently, the thesis combines different works that have been done about Permaculture and comes up with solutions for the planet (support economically the inhabitants of this planet to feed and give them the tools to regenerate the planet). This thesis takes on its full meaning in the fact that even though a few experts have already tried to raise awareness among people to lead them towards the way of Permaculture, authors such as Mollison and Holmgren (1979) or Hemenway (2011) have not combined the existing knowledge to confront Permaculture...
with the socio-environmental challenges and have not provided a response to each of these challenges that makes sense to everyone. Also, although these same authors provided some guidelines to replicate Permaculture and apply it in daily life, then again they did not do it in the perspective of helping people to support their need and protect their environment at the same time. The point of this thesis is to bring out concrete applications and explicitly say in what way it can genuinely support people’s daily life and their environment.

1.3 Research method

To write this thesis, a literature review method was made. Several books and various articles, as well as various studies about Permaculture were produced (Mollison & Holmgren, 1978; Mollison 1988; Holmgren, 2002; Faruqui & Al-Jayyousi, 2002; Wills, Chinemana, Rudolph, 2009; Faber, AS Phungula, Venter, Dhansay, Spinnler Benadé, 2002; Remiarz, 2013). Therefore this paper is a work of research gathering in order to answer a problem. In addition, elements taken from Permaculture websites and YouTube videos was integrated in the research to bring more depth into the analysis. For lack of support from main medias and newspapers, Permaculture can truly exist only through the Internet and through the new and independent media support of today; videos.
Chapter 2: the productivity of Permaculture

2.1. Definition of productivity in terms of cultural systems

According to the business dictionary, productivity is “a measure of the efficiency of a person, machine, factory, system, etc., in converting inputs into useful outputs. Productivity is computed by dividing average output per period by the total costs incurred or resources (capital, energy, material, personnel) consumed in that period. Productivity is a critical determinant of cost efficiency”.

That being said, this general definition cannot be applied everywhere, as each case has its specific definition of productivity.

2.1.1 Agriculture definition of productivity

Agricultural productivity is measured as the ratio of agricultural outputs to agricultural inputs. In Agriculture, products are measured according to their weight or volume. However, as there are many different agricultural products, the question that naturally arises is how to combine them given that the sums of weights or volumes are not very relevant. The most common answer to that issue is to measure outputs in Agriculture in monetary units by calculating the sum of the value of the entire production minus the value of intermediate inputs originating from the agricultural sector. Both cash and non-cash (barter, trade and self-consumption) transactions of final products are to be included. This is referred to as “final output”. Output is usually measured as the market value of final output (excluding intermediate products such as corn, which is used to feed animals in the meat industry).

2.1.2 Permaculture definition of productivity

The definition is different for Permaculture. According to Holmgren (2002), “the lack of conceptual tools to incorporate previously ignored environmental "givens" into calculations used by economists and decision makers is painfully obvious”.
Since Permaculture insists on the integration and interactions of the lands, animals, people and the environment, since Agriculture’s purpose aims to protect and values more these elements than money, Permaculture productivity is usually not measured in monetary units, but in energy invested. Therefore, productivity is the ratio between the total production (output) of the system and the total energy invested (input) to produce these outputs. This energy can be measured in calories.

### 2.2 Labor, planning and input costs

Costs in Permaculture are divided in two categories. First, the labor costs. A person or a household that has decided to start in Permaculture can choose to either learn how to plan and design a Permaculture farm, or to participate in trainings offered by successful professionals of Permaculture. Indeed, Permaculture requires a thorough process of planning and design beforehand, otherwise the risk of errors is high and this might cost much more in the end than trainings. Thus, the primary costs of Permaculture are related with training and design. One of the trainings is called the Permaculture Design Certificate. It is a seventy-two hour (minimum) training experience. Students who complete the full curriculum earn the internationally recognized Permaculture Design Certificate. It provides an introduction to Permaculture design as set forth by the movement’s co-founder Bill Mollison. This program can be delivered at approximately 35 USD per participant per day. When it comes to more basic courses, costs are usually cheaper, reaching around 10 USD per day per participant for a total duration of 5 days. However, prices can be very variable depending on the country and the quality of training. For example, in France, the association Permaculture Sans Frontières provides long-term trainings (15 days), from beginner to advanced, for a price of 100 USD a day (including accommodation). Even though Permaculture depends a lot on the integration and interactions between the different elements of the system that are mostly plants, it does not require a thorough botanic knowledge, basics can be learned step by step along the implementation. Other costs have to be taken into account such as equipment and land costs. Regarding equipment costs, as an example Les Jardins de La Grelinette, a 1.5-acre (6000 square meters) Permaculture farm in Quebec (Canada) invested a total of 39,000 USD in standardized equipment, which turned out to be
very profitable investment afterwards. Naturally, these costs are also variable depending on
the size of the farm. The same goes for land cost, but for this thesis, people who already have
a cultivable land will be addressed. Then come implementation costs. They are based on the
availability and state of local resources as well as the overall design (simple versus
sophisticated). Often, manual labor to prepare and decompact soils will be required, given the
poor quality of soils today. Depending on whether household/persons do this job on their own
or if they get any sort of help from communities to provide resources, labors, etc., costs can
be reduced or even non-existent (but it will take more time). In France, Christophe Koppel
evaluated the time labor cost that he spent to get started with his Permaculture garden and
prepare his land. According to him, a land of 200 square meters needs six weeks of work (1
person) for cleaning, grinding, staking, decompaction of the soil, embankment, straw-
mulching, staking, greenhouses settlement, etc. Back to les Jardins de la Grelinette, the
outside labor of their 1.5 acres property - which is much bigger than the property of
Christophe Koppel – is done by the owner-operators with the help of either one or two
seasonal workers, depending on the area under cultivation and the number of greenhouses.
Even so, time and labor might be relatively high at the beginning but notably decreases -
along with the increase of food production - as the system becomes self-reliant with time.
Benefits usually come within the first 3-6 months. The same Permaculture gardener
Christophe Koppel claims to only spend 1 hour and a half (1 person) every two days for
harvesting and doing various side tasks (transplant, straw-mulching, etc.), as well as one day
(1 person) every season for sowing, taking plant cuttings, straw-mulching and seeds collection.
Finally, specific needed resources vary based on the initial design of the system and the
resources available in the region.

On the other hand, very few input costs (if any) are required to get a functional and
sustainable system. Indeed, a well planned and designed system, following the Permaculture
principles mentioned in the first chapter, disposes of elements that provide the necessary
needs and gets their supplies from other elements of the system. In other words, the outputs of
some elements are the inputs of others. It is what is called a closed system, a self-regulating
system. The elements of a Permaculture system do not depend on external elements, contrary
to open systems such as chicken farms, which need grains, antibiotics, etc. to sustain. Plus,
waste from each element is going to be used as a resource to provide for the other elements. For example, plants produce nutrients for animals. Mushrooms feed plants in nutrients and water thanks to their roots. This is why almost no inputs are used in Permaculture gardens. Chemicals, tiling, digging (aside from the first year), added compost, treatments, mechanization and machinery (purchase, non-renewable fuel, maintenance, etc.) are not used in Permaculture, hence notably decreasing costs compared to other conventional methods. The only inputs left are amendments for soil, seeds and plants protection products, which are generally fairly low and most of the time only needed at the initial stage.

2.3 Output benefits

There is a myriad of outputs in Permaculture, which probably represents its highest strength. As stated in the previous part, outputs of one element in the system are to be efficiently matched up with inputs of another element.

Figure 4: Functional interconnections between elements
Mollison (1991) described the functional interconnections occurring in a Permaculture system. Chickens and fishes eat the dropping fruits of the mulberry tree. In return, chickens can fertilize the pond and the tree through their droppings, which will provide more biomass to the pond to the benefit of fish and seaweeds. Duckweeds will then flourish on the top of the pond and will be eaten by chickens, offering them higher protein content that will help then to produce better quality eggs. The tree will then use the pond as a light reflector and a moisture source. All of this is doable because the elements are placed right next to each other, making then possible the access to the other elements’ outputs that will serve as their own inputs. Thus, it is crucial to perform a profound observation of what happens in nature and natural ecosystems to figure out what outputs can be a good match for inputs. In that way, the system can gain more profitability thanks to relative location and smart interactions. With the food web growing and becoming more complex, there is less waste and more products, ultimately boosting the profit.

What must be kept in mind is that humans in Permaculture are fully incorporated to the system. The outputs of humans, similarly to chickens for example, can fertilize the plants, and reciprocally, humans get their food from the abundance of plants (abundance coming from a high productivity). The most productive plants that a human can get his food from are trees. Trees provide fruits, nuts, and leaves, which are edible in some cases. A common tree possesses 100 of hectares of leaves, which can represent a huge quantity of food for humans. At any rate, even if humans do not want to eat leaves, there is more than enough food produced by the whole system to sustain humans’ needs. The French Permaculture gardener Christophe Koppel has achieved to feed his vegetarian family composed of 4 persons, only thanks to his garden during 10 years. In other words, he has not stepped into any kind of grocery stores to buy food for the past 10 years. Again in France, the National Institute For Agricultural Research realized a scientific survey to observe a small Permaculture farm during 4 years and concluded that Permaculture was a profitable activity. The farm in question is a 1000-square-meter property capable of generating an hourly wage from 6 to 10.6 USD for a
43-hour week due to a high productivity, that is to say a monthly net income from 1000 to 1775 USD. Another farm, the 1.5 acres Market Garden from Quebec already mentioned above also managed to become steadily productive enough and therefore profitable. In 2013, they sold 140,000 USD of vegetables produced on site, with expenses representing 75,000 USD, thus generating 65,000 USD of profit (~45% profit margin). Thanks to this revenue, they can achieve to live a decent life.

Finally, another survey was made by the Permaculture Association in the United Kingdom and led by Van Der Velden (2015), a plant ecologist who has been working to investigate productivity of household systems using mixed vegetables systems. They sent out a low diversity mix of vegetable seeds (3 different species) and a high diversity mix of vegetable seeds (12 different species) to 26 volunteers. They gave them growing instruction and asked them to measure the yield of their production after they harvested. The high diversity mix obtained higher productivity than the low diversity mix, even in regions with harsh climate where they obtained a pretty fair yield. The results are as follows:
- Average yield: 35 tons per hectare in one year
- Highest yield: 100 tons per hectare in one year
The survey does not stop here: calculations have been made afterwards to measure these results at larger scales. Even so, at this point the conclusion can already be drawn: Permaculture methods can get a pretty decent yield and more diversified crops result in a higher yield, even in such a harsh climate like northern UK.

Eric Escoffier (2013) draws up a small comparison with Agriculture productivity and Permaculture productivity. He declares that in Agriculture - going back to the definition of productivity – 15 calories (inputs) are invested to reap 1 calorie (output). Among these 15 calories, 9 are spent in fossil fuels. As food production, Agriculture shows a remarkable inefficiency in terms of input/output ratio and is consuming all the capital and resources of the planet. Quite the reverse happens for Permaculture. Indeed, natural systems invest 1 calorie (input) to reap 10 to 20 calories (outputs). In comparison, the different types of Agriculture have an average productivity from 150 to 400 times weaker than natural systems.
2.4 Contribution of Permaculture to dietary, income and basic household needs

To begin with this part, the survey made in the United Kingdom regarding the mix vegetables systems needs to be further studied. After getting the results of the survey, they scaled them up by doing some calculations in order to get a glimpse of what impact this production could have on a much larger scale. They observed that there are 216 millions of households in Europe. Among these households, 15% - which represents 324 000 households – possess a land where they grow their own food. Permaculture Association found out that if all these households could produce a 10 x 10 meter plot of food using their system, they could produce over a million tons of food a year. Furthermore, question was asked about how people perceived the activity of growing their own food. The answer was these households do not see it as a job, they see it as a leisure activity, an enjoyment activity and a learning activity. Therefore, if all the households agree, potentially 75.6 million tons of food could be grown in Europe just in households. Of course, some are bigger; some have more land, some less, etc. Nonetheless, these calculations were made so as to get a rough idea of the food production potential that could be done with the help of Permaculture techniques. And the potential turned to be quite interesting. Small amounts duplicated on a larger scale can have a big impact.

2.4.1 Contribution to dietary households needs

Implementing Permaculture in households would benefit society as a whole because it has the potential to help families individually. As many Permaculture professionals say, such as Eric Escoffier (2015), it is perhaps the time to “claim back the ownership of our production means”. It is perhaps the time to take with old rural traditions and decide to grow our own food. Not only this is doable, but also the benefits that can be taken out from this are quite considerable.

In 1997, the Cooperative for Assistance and Relief Everywhere (CARE) in Australia implemented a Permaculture Pilot Project (PPP) at a kindergarten in Ain El Baida, a suburb of
Tufileh, Jordan. The project turned to be very successful and was implemented afterwards by Ain El Baida Voluntary Society on larger scales as they loaned money to 50 poor families to implement the PPP in their own homes. The project was to grow many types of fruit trees and vegetables (olive, grape, cucumber and tomato), as well as small animals (rabbits, goats, chickens and pigeons) using a rooftop rainwater systems and greywater reuse systems to irrigate the production (in the case of the kindergarten, greywater was derived from hand washing). Following this, the International Development Research Centre (IDRC) evaluated the consequences of the project. They did a survey of 15 families out of the 50 that received a loan to help them in the implementation of the project. Most families in the survey (87%) used part of the loan to use greywater coming mostly from the kitchen and the bathroom to irrigate vegetables, fruits and herbs.

Figure 5: Greywater irrigation system


The results of the survey showed that a Permaculture project using greywater irrigation systems could considerably help poor urban populations. Although Jordan has a human
development index higher than most developing countries, about 7% of its population is below the poverty line of 1 USD a day. Furthermore, because of its scarce water resources and rapidly growing population, the poor, who are increasingly moving to cities, face growing food and water insecurity. Even so, thanks to this project, the urban poor of Ain El Baida increased their access to food and water, especially in a region where water is scarce. They also improved their food and water security since they had access to more nutritious food that they could not grow before under ‘usual’ conditions, so they were able to diversify their production. Finally, they were able to save valuable fresh water for drinking instead of irrigating.

Wills, Chinemana and Rudolph (2009) realized a similar survey in Johannesburg, South Africa. The survey is based on a project called the Siyakhana project. This project aimed to set up a plot of land of 1 hectare in Johannesburg City Parks in 2006 with the objective of growing fruits and vegetables and providing food for children attending early-childhood development centers and for the beneficiaries of non-governmental organizations providing home-based care for people living with HIV/AIDS. Again, a survey was made to measure the impact of the project on this South African population. Although the impact on health is not yet measurable, the project still improved food security in this urban area given that it increased their consumption of fruits and vegetables (the amounts of fruits and vegetables available and consumed in South Africa being quite low). The knowledge that they acquired also helped them in their choices and improved their overall health (what to eat, what not to eat, how to effectively use medicinal plants, etc.).

These two projects partly proved that diversification of food that Permaculture helps to ensure food security thanks to the diverse diet it can provide, but also thanks to the positive interactions that the different elements of a Permaculture system have, bringing up a better yield and better output quality. In addition and maybe more importantly, a Permaculture system relying on diversification helps to ensure a year-round food security since foods of the systems are harvested at different times of the year. Therefore, a shortage on food seldom appears as there is a constant food supply based on diversification. This is in total opposition with monocultures such as monocropping (wheat, corn). Indeed, they only benefit from two
massive harvests a year but are unable to ensure a healthy diet. Plus, their harvest production can only last one season. Even so, Modern Agriculture has brought an excessive focus on growing just one single crop, providing their population a diet centered too much around a type of cereal. This cereal centered diet leads to undernutrition (lack of protein, fat and micronutrients). Permaculture at the contrary decreases this undernutrition with its diversification-centered diet.

A last survey realized in South Africa further demonstrates the overall increase of nutrition due to access to diverse food. In this country, as in many other developing countries, Vitamin A deficiency continues to be a major health problem, especially among pre-school children, whose intakes are low and who belong to populations that cannot afford to buy supplements. In that context, a study was carried out in Ndunakazi, a mountainous rural village in South Africa. A home-gardening program, focusing on the production of yellow and dark-green leafy vegetables was implemented with a community-based growth-monitoring system in this village. The results are as follows:

- Establishment of 126 home gardens within the village
- Increase of yellow and dark-green leafy vegetables daily intakes among children
- Percentage of children who consumed provitamin A–rich vegetables at least once a week increased (range: 2 to 68%)
- Significant increase of serum retinol concentrations (Vitamin A) among children

Thus, a home-gardening program focusing on the production on yellow dark-green leafy vegetables significantly increased the Vitamin A intakes of pre-school children in a South African village.

### 2.4.2 Contribution to income and basic needs

To elaborate this part, some of the different studies mentioned in the previous parts must be further studied, which results also show a significant help for income and basic needs coming from Permaculture. In the case study of Jordan (Wills, Chinemana, Rudolph, 2009), greywater was reused in a system aiming to grow several kinds of fruits, vegetables and small animals in an urban area. Following this experiment, various economic results that were not mentioned earlier came up. The first result that is worth mentioning is the fact that all of them
were able to pay back 100% of the loan. Indeed, a loan was granted to the adopters who chose to participate in this experiment. Besides, all the households reduced their food expenses, due to their own food growing system. Thanks to the success of the project, about one third even obtained surplus and decided to sell it to generate income. On average, 10% of all the household income was saved. Among them, the poorest participants saved up to 44% of their income.

Table 2: Ain Al Baida Permaculture and Greywater Reuse Project: Income (JD) generated per year

<table>
<thead>
<tr>
<th>Family No</th>
<th>Sale of crops</th>
<th>Family use of crops</th>
<th>Family use and sale of crops</th>
<th>Total income</th>
<th>Percentage generated/cost saved of total family income</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>260</td>
<td>40</td>
<td>300</td>
<td>5520</td>
<td>5%</td>
</tr>
<tr>
<td>2</td>
<td>200</td>
<td>400</td>
<td>600</td>
<td>6000</td>
<td>10%</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
<td>70</td>
<td>190</td>
<td>3960</td>
<td>5%</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>1800</td>
<td>3%</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>0</td>
<td>8</td>
<td>2400</td>
<td>0.003%</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>150</td>
<td>150</td>
<td>2400</td>
<td>6%</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>1680</td>
<td>6%</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>180</td>
<td>180</td>
<td>408</td>
<td>44%</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>360</td>
<td>360</td>
<td>1200</td>
<td>30%</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>180</td>
<td>180</td>
<td>900</td>
<td>20%</td>
</tr>
<tr>
<td>11</td>
<td>100</td>
<td>200</td>
<td>300</td>
<td>1800</td>
<td>17%</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>180</td>
<td>180</td>
<td>1200</td>
<td>15%</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>240</td>
<td>240</td>
<td>1800</td>
<td>13%</td>
</tr>
<tr>
<td>14</td>
<td>100</td>
<td>240</td>
<td>340</td>
<td>2880</td>
<td>12%</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>600</td>
<td>17%</td>
</tr>
</tbody>
</table>

| Averages JD/Year (SUS/Year) | 56 ($79) | 163 ($229) | 219 ($308) | 2303 ($3239) | 10% |

Moreover, had the households used municipal sources for this supplemental irrigation, on average, they would have used 15% more water and had 27% higher water bills, and it does not end here: these savings will be enhanced as more high quality greywater is recovered allowing irrigation of higher value and faster growing vegetables.

Table 3: Comparison of the municipal water cost and the value of greywater collected

<table>
<thead>
<tr>
<th>Household No</th>
<th>Municipal water</th>
<th>Greywater</th>
<th>Greywater / municipal water use (%)</th>
<th>Greywater value / municipal water cost (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quarterly municipal water use (m³)</td>
<td>Cost of quarterly billed water (JD)</td>
<td>Quarterly volume collected greywater (m³)</td>
<td>Quarterly Value of greywater (JD)</td>
</tr>
<tr>
<td>1</td>
<td>48</td>
<td>5.56</td>
<td>9</td>
<td>2.66</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
<td>3.76</td>
<td>9</td>
<td>1.08</td>
</tr>
<tr>
<td>3</td>
<td>66</td>
<td>11.34</td>
<td>15</td>
<td>5.19</td>
</tr>
<tr>
<td>4</td>
<td>57</td>
<td>8.22</td>
<td>8</td>
<td>2.77</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
<td>9.26</td>
<td>5</td>
<td>1.73</td>
</tr>
<tr>
<td>6</td>
<td>N/A</td>
<td>N/A</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>36</td>
<td>4.12</td>
<td>9</td>
<td>1.08</td>
</tr>
<tr>
<td>8</td>
<td>N/A</td>
<td>N/A</td>
<td>4</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>30</td>
<td>3.32</td>
<td>5</td>
<td>0.6</td>
</tr>
<tr>
<td>10</td>
<td>21</td>
<td>2.32</td>
<td>5</td>
<td>0.6</td>
</tr>
<tr>
<td>11</td>
<td>N/A</td>
<td>N/A</td>
<td>8</td>
<td>N/A</td>
</tr>
<tr>
<td>12</td>
<td>55</td>
<td>7.53</td>
<td>4</td>
<td>1.35</td>
</tr>
<tr>
<td>13</td>
<td>23</td>
<td>2.56</td>
<td>6</td>
<td>0.72</td>
</tr>
<tr>
<td>14</td>
<td>50</td>
<td>5.8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>48</td>
<td>5.56</td>
<td>5</td>
<td>1.28</td>
</tr>
</tbody>
</table>

Averages 43.19 5.78 6.67 1.58 15% 27%

Note: Reproduced from Greywater Reuse in Urban Agriculture for Poverty Alleviation: A Case-Study in Jordan, Faruqui & Al-Jayyousi (2002)

And last, depending on the complexity of the greywater reuse system, the average annual cost to collect greywater was 113 USD (range from 45 to 229 USD), while the average net annual benefit was 376 USD (range: from 170 to 615 USD). Hence a very high benefit-cost ratio of practicing greywater reuse, with an average ratio value of 5.3 (range: from 2.8 to 9.4).
Above all, the biggest priority for people willing to start in Permaculture is food-self reliance. In 2013, a general approach survey was produced to investigate on forest gardens – forest gardens display many of the Permaculture characteristics to achieve productivity and resilience – in order to learn more about Permaculture among other things. And so a questionnaire was posted online and was filled by 117 people by the end of 2013. Basic questions such as location, size of sites, goals, achievements, challenges and so on were asked. Various nationalities answered the questionnaire:

Table 5: Distribution of answers per country

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>46</td>
</tr>
<tr>
<td>USA</td>
<td>27</td>
</tr>
<tr>
<td>Italy</td>
<td>13</td>
</tr>
<tr>
<td>Canada</td>
<td>4</td>
</tr>
<tr>
<td>France</td>
<td>4</td>
</tr>
<tr>
<td>Germany</td>
<td>3</td>
</tr>
<tr>
<td>Spain</td>
<td>2</td>
</tr>
<tr>
<td>Belgium</td>
<td>1</td>
</tr>
<tr>
<td>Belize</td>
<td>1</td>
</tr>
<tr>
<td>Croatia</td>
<td>1</td>
</tr>
<tr>
<td>India</td>
<td>1</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1</td>
</tr>
<tr>
<td>Norway</td>
<td>1</td>
</tr>
<tr>
<td>Panama</td>
<td>1</td>
</tr>
<tr>
<td>South Africa</td>
<td>1</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Reproduced from *Forest Garden Research – Finding the Baseline*, Remiarz (2013)
Figure 6: Size distribution of forest gardens

Note: Reproduced from *Forest Garden Research – Finding the Baseline*, Remiarz (2013)

The most relevant data for this part is undoubtedly the answers of priorities and achievements that people who took this survey provided. Of a total of 94 responses, 42 sites (45%) saw food self-reliance as their top priority. Education was the second most frequent answer (21%), followed by biodiversity (19%), whereas only 7.5% have commercial production and only 2 sites research as their most important goal. Furthermore, while food self-reliance was highest on the list of priorities for forest gardeners, the majority stated that their forest gardens contribute to this goal according to their expectations or even better. Concerning biodiversity, answers stated that the achievements were even better than self-reliance. Another very relevant data that came out of this study was the distribution of forest gardens by type of use. Indeed, 60% of forest gardeners use a private garden, 24% use a community garden and 15% of them use a commercial enterprise.
Gathering all these data, the conclusions of the study were that temperate forest gardens exist in many sizes and locations across the northern hemisphere, and for a variety of purposes. They seem to be well suited to contributing towards food self-reliance, as a biodiversity resource and a place for education. However, their commercial use appears to require further development work. Going further, if the results of this survey are linked to the main core of this part, the conclusion is that most Permaculture gardeners first of all look for self-reliance, which seems to be accomplished, sometimes even beyond expectations according to the survey. The most common type of use, which is private garden, is correlated to this top priority goal, as Permaculture gardeners are more willing to grow their food and achieve self-reliance at home, in their backyard or own private garden. The development of community projects is nonetheless sizeable, gardeners are also willing to share their effort and provide self-reliance and biodiversity for themselves and their neighbors. Biodiversity can in turn be correlated to the overall food security and nutrition increase that were mentioned in the previous part.

Figure 7: Distribution of forest gardens by type of use

Note: Reproduced from Forest Garden Research – Finding the Baseline, Remiarz (2013)
To conclude this chapter, due to its high productivity – very few inputs for huge outputs – and its diversity, Permaculture seems to be a very efficient contribution to households dietary needs (health and nutrition improvements), income (surplus are often reached) and basic needs (the top priority for Permaculture is to achieve self-reliance, which is also often achieved).
Chapter 3: Beyond sustainability, a regenerative system

3.1 Definition of sustainability in terms of cultural systems

As what was done in the second chapter when regarding the definition of productivity, here again a general approach must be taken first to define the word sustainability. The General Assembly of the United Nations gave a definition of sustainable development. During the World Commission on Environment and Development in 1987, they defined sustainable development as a “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. In other words, development is sustainable if it does not compromise the ability of generations to meet their own needs.

In Agriculture, the term “sustainable” implies the production of food, fiber, or other plant or animal products using farming techniques that protect the environment, public health, human communities, and animal welfare. Such production allows farmers to produce healthful food without compromising future generations to meet their needs. The Food and Agriculture Organization (FAO 2014) of the United Nations enacted 5 principles as a guideline to respect when trying to achieve sustainability.

Principle 1: Improving efficiency in the use of resources is crucial to sustainable Agriculture.

This principle encourages farmers to modify their current practices in order to improve the productivity of food and agricultural production system. By doing so, it will ensure a sufficient supply of food and other agricultural products while limiting the expansion of arable lands and intrusion in natural ecosystems. Nevertheless, improving productivity will not only mean getting a higher yield any longer. The new productivity will also take into account other aspects such as the environment, water and energy-smart production system as water becomes scarce and greenhouse gas emission needs to be reduced. This will also reduce the use of fertilizers and other chemicals used in Agriculture.
Principle 2: Sustainability requires direct action to conserve, protect and enhance natural resources

To be efficient and produce food, Agriculture needs natural resources. Thus, Agriculture must find a way to sustain the natural resources it uses. Intensification can be done in order to boost productivity. However, an uncontrollable intensification is incompatible with sustainability. It is true that intensification has positive impacts on the environment due to what was mentioned in the first principle: intensification brings about less agricultural expansion and less intrusion in natural ecosystems; even so, it can have a negative effect on the environment when it comes to farm inputs such as water, fertilizers and pesticides. This is unfortunately the most common model of Agriculture, which leads to water pollution, destruction of habitats, soil degradation, and limitation of crop and animal biodiversity.

Principle 3: Agriculture that fails to protect and improve rural livelihoods, equity and social well-being is unsustainable

Through a satisfying control of and access to productive resources, Agriculture must significantly bring wealth and food security in rural areas. Although Agriculture is a direct and indirect source of livelihood for 2.5 billion people in rural areas, poverty is still overly related to Agriculture, given that Agriculture is among the riskiest types of businesses. Agriculture must then provide farmers decent employment conditions (economically and physically safe) and offer them a healthy environment, without which Agriculture will fail to become sustainable.

Principle 4: Enhanced resilience of people, communities and ecosystems is key to sustainable Agriculture

Agriculture is vulnerable to extreme weather events, market volatility and civil conflicts. To contribute to Agriculture’s sustainability, farmers must build resilience to these threats. Climate variability not only caused by the seasonality of temperate climate regions but also by climate change have a considerable impact on farmers and their production. Moreover, with
the advent and intensification of globalization, the risk of food price volatility has significantly increased over the years, increasing at the same time the unpredictable impacts on the production systems. In that perspective, both farmers and consumers struggle to deal with these two threats. Thus, resilience seems to be the only way for Agriculture to reach sustainability.

**Principle 5: Sustainable food and Agriculture requires responsible and effective governance mechanisms**

Accountability, equity, transparency and the rule of law are essential and must be ensured in order to begin the transition towards a sustainable Agriculture. Also, the right balance between private sector and public sector initiatives must be found. Indeed, the public dimension must be added to the economic enterprise dimension in order to incorporate sustainability in food and agricultural systems. Naturally, Agriculture is and will continue to be an economic activity providing revenues and decent life to people who practice it. Even so, farmers of all types, fishermen and foresters must receive the necessary incentives to support and apply the correct behavior while practicing onsite. Sustainability will only be reached through effective and fair governance.
3.2 In what sense Permaculture is sustainable

Permaculture looks at everything people do in life and tries to make it sustainable for many generations to come. Much of this sustainability is achieved by imitating what can be seen in nature. Now, nature and its systems are sustainable by essence. An ecosystem is the whole system formed by an association or community of living organisms (or biocenosis) and its - biological, geological, edaphic, hydrological, climatic, etc. - environment (biotope). The elements constituting an ecosystem develop a network of energy and matter exchange enabling the maintenance and development of life. In the report *Millennium Ecosystems Assessment*, 2004, the United Nations defined an ecosystem as a “dynamic complex composed of plants, animals, micro-organisms and the surrounding still life all interacting as a functional unit”. Ecosystems are naturally well balanced: at each level, biomass - mass of living biological organisms in a given area or ecosystem at a given time - is stabilized thanks to the interactions with the other levels. They are autonomous and of very variable size (a forest and a small pond are ecosystems that do not have the same geographical extent). All of lifeforms living in an ecosystem interact and affect one another. This balance and this auto regulation ensure the sustainability of the ecosystems and are manifested by a very great constancy of the concentration of the various elements present in each ecosystem: this law is called homeostasis and every ecosystem obeys to this law.

As described in the introduction, Permaculture integrates land, resources, people and the environment through mutually beneficial synergies by imitating the no waste, closed loop systems seen in diverse natural systems. In addition, Permaculture imitates the auto-regulated and balanced structure of natural ecosystems, as well as their complexity and diversity. In
other words, Permaculture imitates the sustainability of natural ecosystems that can be found in nature.

To provide more details about Permaculture’s sustainability and in order to further demonstrate the fact that Permaculture is essentially sustainable, the 5 principles mentioned is the first part of this chapter will be broken down in order to see whether Permaculture is able to respond to these principles point by point.

3.2.1 Permaculture improves the efficiency in the use of resources

As a reminder, the first principle of the FAO encourages farmers to modify their current practices in order to improve the productivity of food and agricultural production system that will not only take into account the yield but this time the environment too. This productivity is to make sure to produce a sufficient supply of food and other agricultural products not only to feed populations but also to limit arable lands expansion and harmful intrusions in ecosystems.

As shown in the second chapter, Permaculture productivity completely outranks Agriculture in terms of calories generated per acre. Indeed, as Eric Escoffier observed, 15 calories (inputs) are invested to reap 1 calorie (output) in agricultural systems, while 1 calorie is invested to reap 10 to 20 calories in permacultural systems. On one hand, one system uses 15 calories, thus consumes 15 calories including 9 in fossil fuels to generate only one calorie of food. These 15 calories invested are in most cases harmful for the environment: pesticides, fertilizers that degrade soils and destroy ecosystems. They are also, in most cases, not renewable - such as fossil fuels - and further participate in the exhaustion of the limited natural resources available of this planet. On the other end, another system where the capital of this planet is saved - only 1 calorie invested - and where a small investment as such can generate huge outputs in the range of 10 to 20 calories. Therefore, given that the investment required is much lower to generate the same amount of outputs, Permaculture is already a very good alternative to improve the efficiency in the use of resources.
In addition, prior to the implementation of the systems, Permaculture dedicates a fair amount of time to the design of the system. In the book *Introduction to Permaculture*, Morison (1991) explains how to properly design a Permaculture system so as to obtain an efficiency use of energy. Planning to conserve and make good use of resources (and money) is essential in any good design. Thus, Permaculture uses zones, sectors, and slope in where to position elements such as structures, trees and plants, animals, buildings and water features to make the most efficient use of energy.

First, zone planning is a system where the location of an element is determined by the frequency with which this element is going to be used. As a consequence, the elements that are the most used and need the most attention are located closest to the house. Conversely, the elements that are used the least often are located the furthest away of the house. Everything is placed accordingly to the degree of importance. Doing so allows to get an easier access to the elements that are the most needed, decreasing the amount of energy spent required to access them, thus making a more energy efficient system.

Next, sector planning deals with energies external to the site, the outside elements and forces of Nature that pass through the system, such as winds, sun angles, water flow and flood prone areas, unwanted view, fire danger areas, etc. Because these energies get through the system from outside, in order to benefit from and deal with them, the different elements (plants, trees, structures, etc.) must be strategically placed in the system. With such a design, the incoming energy can either be blocked, channeled for a specific use or an area can even be opened to let the incoming energy in if needed.

Last, slope takes into consideration the site in profile. With slope, it is possible to take advantage of gravitational force to improve the efficiency of the system. Indeed, gravity can move elements from the highest point to the lowest. Consequently, in order to make a more efficient use of resources, it is necessary to place them uphill and use gravity to move them down. For example, as water naturally flows from up to down, water can be harvested at the highest point and rely on gravity to create a drip irrigation system that will move water downhill.
3.2.2 Permaculture conserves, protects and enhances natural resources

In the first chapter, the twelve principles that Permaculture follow as described by David Holmgren in his book *Permaculture: principles & pathways beyond sustainability* were defined. According to the fifth principle, farmers in Permaculture use and value renewable resources and services. Indeed, Permaculture design aims to make best use of renewable natural resources in order to manage and foster productivity, although some use of nonrenewable resources is needed when the systems are established at the beginning. Likewise, renewable resources with passive functions are encouraged in Permaculture. These passive functions are the ones provided by plants, animals and living soil and water, without them being consumed. The best example is tree. A tree is generally used for wood as a renewable resource. However, when a tree is used as a shelter, or when the shade of tree is used in gardening to grow specific kind of plants, advantage can be taken from the living tree that was not consumed (that was not burned to make a fire or used to build something). Therefore, this advantage does not consume and does not require any harvesting energy. Thanks to this simple but meaningful and powerful understanding, Permaculture is able to transit from systems where many simple functions have become dependent on non-renewable and unsustainable resource use to systems making an efficient use of sustainable resources and benefiting from all their functions while not consuming these resources.

Another principle described by Holmgren (2002) shows how Permaculture improves the efficiency in the use of resources: it is the 6th principle. Produce no waste, or in other words, make the best use of all the outputs generating by the system. Permaculture responds to this criterion as it gives a role to all the outputs of the systems. Nothing goes to waste as every output will be used by at least one of the components of the system. Nothing becomes a pollutant as Bill Morison defined it – “an output of any system component that is not being used productively by any other component of the system”.

Therefore, in Permaculture, all the resources of the system are being productively and efficiently used.
3.2.3 Permaculture protects and improves rural livelihoods, equity and social well-being

The objective of this principle is to ensure that “producers have adequate access to and control of productive resources”. Can Permaculture “provide decent employment conditions to those who practice it, in an economically and physically safe, healthy environment”, as suggested by the FAO?

The various surveys portrayed in the second chapter made evident the role that Permaculture can play in providing the access to and control of productive resources. The urban food garden in Johannesburg enabled people who decided to get involved in the project to become gardeners, and then get a job. The project was to give a plot of land of a hectare to the participants with the aim of growing fruits and vegetables to the benefit of people who took care of the plot, while training them to provide themselves sustainable and healthy habits as well as income. Therefore, the project succeeded in generating employments that enabled them to get access and control to productive resources, economically sustainable and within a healthy environment. Plus, people who participated to the project considerably increased their learning about Permaculture and organic gardening, and increased their human and intellectual capital. The site became a model providing service learning for students. Participants gained knowledge regarding medicinal herbs: what to use and how to use them. They also learned about nutrition and healthy cooking habits. Finally, the project strengthened their social capital by enhancing their community. The project offered a place where people could gather, network and identify themselves as belonging to the same community. Indeed, this Permaculture project demonstrated the development of networking and capacity building around nature: humans are innately made to gather and connect to nature.

The greywater reuse project, in turn, showed the significant social impact - including community strengthening and even gender dimension - that Permaculture had over population of the Jordan small urban area used for the experiment.

Thanks to the project, families were able to save a decent amount of money as well as generate income for their daily needs. But also, the project enabled them to get employments
and valuable skills. Permaculture even tackled the problematic feelings obtruding the access to development such as dependence, worthlessness and hopelessness that are often greater obstacles to development than money itself. Regarding the gender dimension, this Permaculture experiment gave to the women a major role. They managed the household budget and were responsible for the health and nutrition of the family, 3 key aspects of the project. Furthermore, women are the ones who gained the most from the project in terms of skills and education. Finally, the community became stronger and even grew over the project realization.

3.2.4 Permaculture enhances resilience of people, communities and ecosystems

Permaculture aims at building resilience into systems using the interactions between the different elements included in the system, a phenomena that can be found in natural systems. Designers in Permaculture strive to create stable, diverse, and resilient systems that meet the requirements of humans and all other animals and plants that live in humans’ close environment. A resilient system is a stable system that is able to resist to abrupt changes (disasters, dryness, flood, fire, cold, heatwave, pollutions, diseases, wind, plagues, conflicts, social disturbances, etc.). By definition, it is therefore synonym of homeostasis or self-regulating.

As mentioned above, natural ecosystems including Permaculture – Permaculture imitates the model of natural ecosystems - follow the law of homeostasis and apply self-regulation. This is the first step towards resilience. Indeed, according to the fifth principle of Holmgren (2002) encouraging to apply self-regulation, an auto-regulated system composed of self-reliant elements is more resistant to external disturbances. For example in Permaculture design, it is best to favor robust, half wild and self-procreating crop varieties and livestock species instead of dependent and numerous crop varieties and livestock species. Moreover in the past, farmers applying self-reliance on their site were considered as the base of a strong and independent society. Indeed, a self-reliant system ensures to the community certain independence due to the fact that this community does not rely on external inputs that would
be hard to get access to in case of crisis. Farmers in Permaculture have a total control of all their production means.

Last, as explained in the second chapter, and given that Permaculture systems nurture diversity, diversification of crops, animals, plants (elements of the system) is the best way to ensure a year-round food security. Indeed, the more diverse the system is, the more options there is in choosing what food can be harvested and eaten. Since diverse foods of the system are harvested at different times of the year, people will be less vulnerable in case of external disturbances. Indeed, a shortage on food seldom appears as diversity ensures a constant food supply. As a consequence, Permaculture enhances resilience of people, communities and ecosystems.

3.2.5 Permaculture implies responsible and effective governance mechanisms

Permaculture more than a design method can be defined as an activist movement gifted with its own philosophy and politics. At the beginning, Permaculture was thought to cope with humanity and planet issues thanks to a deep understanding of the nature of problems and a pragmatic approach: understand the problem, come up with a solution and take actions to implement this solution.

Permaculture is a system that is always run accordingly to its three ethical principles - care for the People, care for the Planet, and the principle of fair share. Capable of building communities with an ecological design, Permaculture promotes and values unity, harmony and diversity, as well as nature. In that way, Permaculture goes against the destructive ideology of western societies, where man fear nature and have to control and submit it by any means. Given that Permaculture is also an applied science, Permaculture shares the same values as the ancient Greek philosophers, which are logic, reason and science. Therefore, one of the key values of Permaculture is to foster “cooperation, not competition”. Due to this strong value, Permaculture can bring unity and harmony in order to integrate people instead of dividing them, and build communities.
Consequently, Permaculture is an independent system as a whole that has its own responsible and effective governance mechanisms to ensure accountability, equity, transparency and the rule of law. By enhancing the power of cooperative communities, Permaculture can create its own future, powered by its own ethics that everyone respects, and can lead by example.

3.3 Permaculture goes beyond sustainability: it regenerates

Up to part of the thesis, the term sustainability was employed when writing about Permaculture. Nevertheless, given the current situation of our world described in the introduction of this thesis, sustainability alone might probably not be enough to carry on its shoulder the burden of environmental problems. A nuance should be made in the definition of sustainable development given by the United Nations. As a reminder, the United Nations defined sustainable development as a “development that meets the needs of the present without compromising the ability of generations to meet their own needs”.

According to Hemenway (2011), if this might have been true a thousand years ago when the first civilizations discovered how to make fire or when other civilizations started to develop Agriculture and then first started to pollute the environment due to the inherent characteristics of Agriculture described in the introduction, it is not as true nowadays. Indeed, since then more than 10,000 years of Agriculture have passed and have continuously degraded the environment, depleting natural resources and degrading soils. And this process has drastically seen itself accelerated since the advent of industrial societies and fossil fuels. Thus, when the United Nations state that humanity must aim towards a sustainable development - in other words meet the needs of the present without compromising the ability to meet our future needs -, two questions naturally arose in Hemenway’s mind:
- How is it possible to know that meeting people’s needs of the present is going to leave enough for the future needs?
- How can the word “need” be defined?
Every person has different particular needs, from people to people, from groups to groups, from cultures to cultures, and above all from generations to generations. As a consequence, it is almost impossible to predict what will be the needs of future generations. Given that there is a doubt about whether sustainability enables us to be capable of meeting our future needs, the most careful approach is to go beyond sustainability, to achieve more than just sustainability.

Figure 9: Degenerative, sustainable and regenerative systems

Note: reproduced from Duke's Nicholas School of the Environment (2010), Toby Hemenway – How Permaculture Can Save Humanity and the Earth, but Not Civilization

Seeing sustainability from another angle, Hemenway (2011) defines it as the mid-point between activities that are degenerative, in other words activities that pollute, destroy, damage,
etc. – in fact most of our current activities are degenerative – and activities that are regenerative, in other words activities that purify, restore, create, etc. Sustainability is in the middle of degenerative and regenerative. However, because the world is already so much involved and bogged down in the degenerative side, one must not limit himself in aiming towards sustainability, which is in the middle. People must first shift from degenerative development to sustainable development, and then from sustainable to regenerative development, to make sure that people will be as ready as possible in the future to meet their needs.

Permaculture is here to come to the rescue. In actual fact, Permaculture is not merely sustainable but also regenerative. “Regenerative” means the capacity to “restore to a better, higher, or more worthy state”; hence, a regenerative activity has the inherent capacity to bring itself into existence one more time. Regenerative systems can be considered to continuously improve the world from its current state: for example, creation of habitats, water purification, and improvement of soil (through nitrogen and carbon ratio). Plus, a regenerative activity/system must generate more energy – or calories - than was used in its production. For example, a system that relies on fossil fuels natural gases, fertilizers, etc. such as Agriculture to generate energy is a degenerative system. Reversely, if the by-product of a crop as well as other inputs coming from different elements belonging to the same system serves as future inputs for this crop during the following season, the system can be considered as regenerative. Permaculture, as was already proved in the precedents parts, gathers all these conditions. By essence, Permaculture designs systems so that “each element – of the system - performs many functions” and “each important function is supported by many elements”. In that context, all the elements of the systems are chosen beforehand during the design phase and placed accordingly so that they provide as many functions as possible. The designed system is “resilient”, as explained in the previous part, which means that even if one element of the system fails, the system will not collapse given that essential functions are carried out in various different ways. This can guarantee to the system a continuous longevity through the introduction of multiple systems that support each of particular functions in the design, single points of failure (weak links) are avoided, and the overall system will more likely continue working should any unplanned circumstance prevail. Last, taking the accurate energy wise
definition of Permaculture, the conclusion is that Permaculture is regenerative as it can produce more than it consumes – 1 calorie invested (input) to generate 10 to 20 calories (outputs).
Chapter 4: How replicable is Permaculture and what is required for replication

4.1 Replicability of Permaculture

4.1.1 Reach the sufficient productivity

Permaculture can be an attractive model and a replicable model if it ensures in any case a sufficient productivity to people who practice it, as this is the main objective of most people – cf second chapter - who get started with Permaculture. In Permaculture, in order to reach the sufficient productivity and meet our daily dietary needs, or even support our daily income if people who apply Permaculture decide to sell surplus, the third principle detailed by David Holmgren - obtain a yield - must be respected. The yield that is obtained will determine whether one can be self-reliant in terms of food and even sell surplus or not.

Mollison (1988), in *Permaculture: A Designer’s manual* insists about yields and explains the different strategies to create them. He divides yields into two distinct categories: palpable, material yields and impalpable yields. Among the palpable ones, there is the product yield, which “the sum of primary and derived products from, or surplus to, the system” and the energy yield, which is “the sum of conserved, stored, and generated energy surplus to the system” (Mollison, 1988). Regarding the impalpable yields, they are related to lifestyle, social context, security, nutrition and health. In most systems, the yield is designed based on their productivity, whereas in Permaculture, the main concern is that the yield must be sustainable. Indeed, Permaculture focuses on productive use: the energy used is turned into biological growth and will be used as a resource in the ecosystem. If unused, these energies can become harmful for the other resources and end up decreasing yields. The task is therefore to store, conserve and convert these energies belonging to or passing through the system into useful elements.
Last, after having observed nature for a while, Mollison (1991) stated that living beings on this planet are the only ones who can effectively use resources and produce yields. As a consequence, the total yields and surplus generated by the design are determined by the sum and capacity of these living beings. Here are some of the strategies imagined by Mollison (1991) to create yields:

“**Physical-Environmental**
- Creation of a niche in space; provision of a critical resource
- Rehabilitation and creation of soils
- Diversion of water, water recycling
- Integration of structures and landscape

**Biological:**
- Section of low-maintenance cultivars and species for a particular site
- Investigation of other species for usable yields
- Supplying key nutrients, biological waste recycling

**Spatial and Configurational:**
- Annidation of units, functions, and species
- Tessellation of units, functions and species

**Temporal:**
- Increasing cyclic frequency
- Tessellation of cycles and successions, as in browsing sequences

**Technical:**
Use of appropriate and rehabilitative technology
- Design of energy-efficient structures

**Conservation:**
- Routing of resources to next best use
- Recycling at the highest level
- Storage of run-off water for extended use

Cultural:
- Removing cultural barriers to resource use
- Expanding choices in a culture

Legal/Administrative:
- Removing socio-legal impediments to resource use
- Creating effective structures to aid resource management

Social:
- Cooperative endeavors, pooling of resources, sharing
- Financial recycling within the community

Design:
- Making harmonious connections between components and sub-systems
- Making choices as to where placing things or how to live”

Thus, the potential productivity of a Permaculture system is not only defined by product yield, but also by energy yields, which depend on the quantity and the choice of strategies applied. Plus, our behavior, knowledge and skills have an impact on yields. While nature is left to its own devices, Permaculture can make a difference in a way that people can intervene and provide the missing elements or even guide the system.

4.1.2 Ensure sustainability of Permaculture

A replicable system must also be able to ensure its own sustainability. In this part, the process of ensuring a system’ sustainability will be explained.
First, a low-inputs strategy must be followed. Outside funds and outside resources must be avoided as much as possible so that to make possible the replicability. Indeed, the more
dependent a system is towards outside resources, the more difficult it becomes to replicate it. To implement this strategy, Permaculture farmers must ensure to build a self-reliant system. Self-reliance and auto regulation are the two keys to considerably limit the dependence on external inputs. Stacia (2005) states that it is a matter of knowing the impact that a high-input strategy can have on farmers and where this dependence can lead. According to Stacia (2005), the method used to produce maize in Malawi in 2005 was destroying the environment and many people were stuck in a ‘Cycle of Dependency’, without being truly capable of getting away of it.

1.) New Crop, Maize: Farmers are encouraged to abandon traditional food sources for higher yielding hybrids such as maize.

2.) Change in diet: Maize takes over as the crop of choice. Early yields, as promised, are extremely high.

3.) Money Required: The higher yields, however, carry a price. Hybrid seeds are not self-replicating and therefore need to be repurchased each year. Maximum growth is encouraged through the use of expensive chemical fertilizers.

4.) Soil Destroyed Successive maize crops on the same soil combined with the “slash and burn” method of preparing for each year’s planting begins to take its toll. As less organic matter is added back into the nature cycle, more chemical fertilizer is needed to maintain the yields.

5.) More fertilizer, less money: Local farmers are forced to sell off more and more of their yields in order to cover the costs of the increased demand for artificial fertilizer and new seed. Less food ends up being

6.) Dependent on Inputs Farmers end up caught in a “cycle of dependency” where each year they are dependent on buying seed and chemical fertilizer to ensure a harvest. Many find that they can barely afford to produce enough maize to meet both their food needs and their expenses.

7.) Forgotten alternatives Over reliance on a single crop causes susceptibility to drought, pestilence, crop disease, and a poor diet—which in turn increases vulnerability to malnutrition and human diseases. As this dependency grows, alternatives disappear. The knowledge of indigenous plants that had once been used or grown as food crops slowly fades out of memory, and people become locked even deeper into this detrimental cycle.

Figure 10: Cycle of Dependency,

The second point in the process is to encourage multifunctionality. Indeed, Permaculture farmers during their design phase must favor elements – plants, animals, structures – that have more than one function (at least two or three functions minimum). These elements should be used to provide food for people, for soils, for ground protectors, etc. The best example is trees, elements that have serve as many functions at the same time.

Table 6: Principle of multifunctionality

<table>
<thead>
<tr>
<th>Products</th>
<th>Environmental</th>
<th>Structural</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Fruits</td>
<td>- Windbreaks</td>
<td>- Privacy screen</td>
</tr>
<tr>
<td>- Nuts</td>
<td>- Fire control</td>
<td>- Trellis for vine crops living fence</td>
</tr>
<tr>
<td>- Edible seeds</td>
<td>- Erosion control</td>
<td>- Shade</td>
</tr>
<tr>
<td>- Essential oils</td>
<td>- Wildlife habitat (both alive and dead – e.g. dead hollow logs)</td>
<td>- Biotecture</td>
</tr>
<tr>
<td>- Fuel</td>
<td>- Climatic buffer</td>
<td></td>
</tr>
<tr>
<td>- Timber</td>
<td>- Soil conditioner</td>
<td></td>
</tr>
<tr>
<td>- Biomass/mulch</td>
<td>- Cycles water via evapotranspiration</td>
<td></td>
</tr>
<tr>
<td>- Animal forage</td>
<td>- Cycles deep nutrients</td>
<td></td>
</tr>
<tr>
<td>- Medicine</td>
<td>- Shades out some undesirable species</td>
<td></td>
</tr>
<tr>
<td>- Oxygen</td>
<td>- Fast growing pioneers produce shade for other species</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Berms/swales (dead trees on contour)</td>
<td></td>
</tr>
</tbody>
</table>

Note: reproduced from *Principle of Multifunctionality*, Brett (2016)
Thus, trees form an essential component in every Permaculture designed system and must be included to reach sustainability and facilitate replicability.

The third important point of the process is community support and involvement to make Permaculture sites sustainable. The Siyakhana project showed the importance of community in establishing sustainable Permaculture gardens. The project aimed to build a food garden in the center of Johannesburg. The success and sustainability of any project depends first on the motivation and on the involvement of each participant. For this particular project, the involvement was quite considerable. During the project, a participant - whose name was not provided - testified:

“I am a community person, my life is rooted in the community and I always want to know what is happening in my community, so that inspires you to want to do this for the people … it's a commitment which you have in the community” (Participant 3, 2006). Even one of the stakeholder – again, his name was not provided - of the project stated that: ‘Community development is made or broken by the community themselves. Successful projects all have in common a dynamic, motivated community member or members to lead the project … one of the things we decided very early on as an organization was only to work in response to actual community requests for projects and every time, 100% of the times when we receive a request from another organization on behalf of the community - those projects have not been successful” (Stakeholder funder, 2006). The second reason why community is essential is related to the input costs. While input costs should be kept at the minimum, in some situations a Permaculture project requires to invest some money at the beginning to cover the costs. The community can cover these start-up costs. Sometimes, aside from providing funds to the project, the different participants can provide resources such as tools, seeds, labor, etc. in order to support the progress of the project and make the implementation free of any costs. All the communities are willing to do so because they aim towards general benefit of the whole community. By doing so, they are able to empower themselves and strengthen their community.

Finally, to make Permaculture sustainable and replicable, it is crucial to undo all the myths and beliefs representing a barrier to the establishment of Permaculture, while expanding the
understanding. Two examples can illustrate this statement. The first example is the idea that sweeping the ground around buildings to compact the earth and remove vegetation is synonym of cleanliness, order and good hygiene, while it is actually the opposite. Permaculture encourages using all areas and planting crops around buildings, while keeping a minimal sweeping to clean the main pathways. The debris would be used as a mulch to improve soil fertility and structure and to provide nutrition for the system. The second example is the belief that only poor people eat indigenous foods. Indeed, many nutritious, healthy and local plant and animals resources are being ignored and forgotten in many countries, while it could benefit the whole population. Blowing away these negative beliefs must be one of the duties of Permaculture, and this can be possible through a thorough education.

4.2 Education to foster replicability

4.2.1 The role of education

According to the definition of UNESCO (1960), “Education should be a means to empower children and adults alike to become active participants in the transformation of their societies. Learning should also focus on the values, attitudes and behaviors which enable individuals to learn to live together in a world characterized by diversity and pluralism”. In addition to this definition, education is a powerful means to sensitize children or adults about the current problems of the world (poverty, disparities, inequalities, environmental problems) and teach them how to face the challenges of tomorrow.

A new form of education has already emerged in the world, aiming to enable individuals and communities to grasp the complexity of the natural and man-made environment, complexity due to the interactions of its biological, physical, social, economic and cultural aspects. This education is called the Environmental education (EE). Indeed, the EE seeks to teach knowledge and values, promote behaviors and develop the skills needed to a responsible and effective participation in preventing and solving humankind problems related to the environment, and in preserving (or restoring) the environmental quality. Thus, the
sensitization about protecting the environment has already started. UNESCO states that EE is crucial to arise respect for nature in our societies and to increase our environmental awareness.

However, this initiative that was taken at a global scale in the 90’s was not enough to make a difference. Today, the world is still facing the same challenges and is still struggling to overcome them. As a result, it is necessary to try to educate people at a smaller scale, a more local scale. Today, only teaching them what are the challenges and just sensitizing the population about the environment and social problems is not enough. Indeed, it is necessary to go further than these first steps and teach people how to deal with these challenges, teach them what are the solutions. And as was demonstrated along this thesis, Permaculture pretends to be the fastest, easiest and most effective solution to face the humanity and planet challenges. Therefore, Permaculture knowledge and values must be taught and spread among children, adults, schools, etc. in order to implement a solution to save the planet and live a decent and sustainable life, without compromising the future of next generations.

4.2.2 Learning then teaching Permaculture

There are several ways to learn about Permaculture. The first one, which was already mentioned in the second chapter, is to participate in trainings. The most common training is the Permaculture Design Certificate (PDC) Course, which is a training based on Bill Mollison’s teachings of Permaculture design system. This course teaches a basic understanding of design and development principles involved with large scale and small scale intensive Permaculture applications. At the end of the course, students earn a certificate meaning that they have completed the course and use the word “Permaculture”. Moreover, students learn a set of useful skills for starting and applying Permaculture (whole farm planning, vegetable and fruit production, comprehensive planning and design for the built environment, etc.).

The second way to learn is to join WWOOF (Willing Workers On Organic Farms). WWOOFing is a worldwide network of organizations, bringing volunteers and organic
farmers together, and helping people share more sustainable ways of living. In return for volunteer help, WWOOF hosts offer food, accommodation and opportunities to learn about organic way of living. WWOOF organizations link people who want to volunteer on organic farms with farmers who are looking for volunteers willing to learn and live a new experience. WWOOFing also exists in Permaculture, as Permaculture also advocates an organic lifestyle. Therefore, WWOOF can be a very effective way to learn Permaculture given that volunteers get a direct application of Permaculture principles on a daily basis, and evolve in an environment filled with the ethics and values of Permaculture. Financially speaking, it is free since it is a sort of work exchange: the hosts provide what is needed (accommodation, food) to live on the farm in exchange for work.

The third way is to autonomously acquire knowledge and experience via books and videos. The budget is also low, but the progression is slower. After doing so, the first part of the learning must be followed by a practice on site. People can either start their own projects or help a friend or even work on a community project to put in practice the knowledge they acquired. Trials and errors can be a great learning process, however, it takes more time and energy.

The last way is the schools and universities that offer a Permaculture course to the students. However, there are only a few in the world and people can only expect to witness the expansion of this course among schools and universities of the world.

The next step, after learning, is to share the knowledge and teach others about what people have learned in return. Take and give, accordingly to the third ethics of Permaculture – fair share -. Moreover, the National Training Laboratories found out that the best and most effective learning method is to teach what have been learned. In other word, when someone is a teacher, he/she must find a way to get his/her student teaching, and when someone is a student, he/she must seize every opportunity that will lead him/her to teach even though he/she might not feel confident about something that has just been learned.
Figure 11: Learning pyramid.

Note: reproduced from the National Training Laboratories, Bethel & Maine (1960)

To implement a class that is interactive, engaging, interesting and fun at the same time, while also giving students the confidence and the opportunity to practice their teaching, the teacher will have to come up with activities where students can share their skills and knowledge about various Permaculture topics.

4.2.3 Example of the Permaculture classroom

In Oregon (USA), an outdoor classroom project came into being at the Hood River Middle School Outdoor. In 1998, the science professor Michael Becker launched this Hood River Middle School Outdoor Classroom Project, a program using a Permaculture and ecological based framework, in order to offer his students a greater connectivity between the Hood River Middle School and their community, as well as connect them to real world issues that they will be likely to face and how to tackle them. The project is still going on today and has been a successful example in the US.
Hood River Middle School is a public school bringing for the first time into life the student-led Permaculture program, implemented by the professor Michael Becker. This school is quite unique due to their approach to education: students are the actors of their education. Guided by their teacher, they design and implement themselves Permaculture projects. Everybody can choose his/her own project and students can work in groups to do the project. Projects range from growing food using Permaculture methods to building aquaponics systems, building a toll storage shed or even building and cooking with a cob pizza oven. The food produced is used for the school canteen or is sold at the market. This program teaches students practical and theoretical skills. Not only students learn how to plan, grow, harvest, market and sell food, but they also learn about ecology, math, and even get entrepreneurial and project management skills along the process. This program does not infringe upon conventional course required by the state. Students in that school are 12 to 15% above the average in most categories regarding the state tests. Here is what the teacher Michael Becker says about the program: “For the last ten years -- through the Food and Conservation Science Program (FACS) -- my students at Hood River Middle School and I have been designing, building, and operating a Permaculture-inspired system that allows the depth, complexity, and ownership required to move from a linear pedagogy to a systems-based approach offering the variables and relevance that my students devour”. Michael Becker, through this program, wanted to empower his students and enable them to fully use their “tremendous potential as change makers in their communities” (Becker, 2016, para. 5).

This example shows that teaching people how to be the change makers of their future using Permaculture principle can start from a very simple decision such as implementing an outdoor classroom in a middle school. As it is still too early, the outcomes cannot be measured yet. However, the multiplication of this kind of project could have a meaningful impact on a larger scale.
4.3 Example of applications

4.3.1 Horticultural society

Hemenway (2011) advocates the rebirth of a horticultural society that used to prevail a long time ago. Horticulture comes from hortus, meaning plant, whereas Agriculture comes from ager, meaning field. Horticulture therefore uses gardens rather than farms, along with small hand tools instead of large power tools. The crops are usually mixed (polyculture) and harvested on a small scale (garden scale). Horticulture encourages succession and forest growing, which allows ecosystems to function properly. Last, as opposed to Agriculture, horticultural society tends to have a less hierarchical management system but at the contrary much more egalitarian. It is also said that horticultural society deeply cares about the Earth given that they see it as a living being. Horticulture, which can be said to be part of Permaculture as it only focuses on gardening, is one of the most efficient method for obtaining food due to the return of outputs on energy invested (inputs). Furthermore, Hemenway (2011) points out that agricultural societies do not stand for the beginning of human civilizations and human culture. Indeed, horticultural societies had to work less in the past in order to get their food, leaving more time to develop arts, music, medicine, spirituality, crafts, communities, etc.

The idea of Hemenway (2011) with horticulture is to create a post-industrial horticultural society based on the principles of Permaculture. He is well aware that things have changed since the time when horticulture was at its moment of glory. Therefore, he suggests taking an approach based on the fact that the accumulation of details and small actions can make a difference in the end. He provides some example.

The first example is a regenerative design project on a site in Nothern California (USA). There was an area in Sonoma County where the soil was eroding seriously with a very bad quality - this soil had been used for grapevines for a long time -. The purpose of the project was to build a house in the middle of the area and regenerate the land surrounding the house.
It was a regenerative construction project. Using nature around and Permaculture principles, they managed to rebuild a quality land and create habitat.

The second example illustrates well the Permaculture principle “make the least change for the greatest effect”. In Portland (USA) traffic circle. There was a very dangerous intersection with a myriad of cars crossing their pathways. Populations living around this intersection were afraid for their kids and themselves to get hurt, so they asked the local government to build a circle intersection. However, the local government refused, claiming that it would be too expensive. Since they did not want to wait for the decision to be unblocked, they decided to act themselves. They painted the intersection. By painting intersections, they made this place look less like a highway on which cars are the priority traffic. Indeed, drivers expected to cross a pedestrian crossing the road slowed down considerably. As a consequence, this initiative had various benefits on the community living around this intersection. It strengthened the community because they had to gather and work together to make the project possible, it created a safer place for the inhabitants of this neighborhood, and reduced insurance costs due to fewer accidents on the road, without costing anything to the city. The project was a success and gave birth to The City Repair Project, which works with Permaculture landscaping, natural building, and intersection repair (painting the street to make a plaza) so as to make the city a better place to live in.

The third example took place in the Bahamas, illustrating the principle of “catch and store energy”. A school in the Bahamas had a problem with their septic system. Indeed, the school was located in a remote area, too far from the city to connect their system to the public septic system. People from the school did not want to throw away all their wastes into the sea. So they imagined a very pragmatic solution. They built two concrete lagoons where they put gravel in it to serve as mulch, and planted various plants inside the lagoons.
Figure 12: 1st stage of the septic system project in Bahamas: construction of lagoons

Note: reproduced from *Duke's Nicholas School of the Environment* (2010), *Toby Hemenway – How Permaculture Can Save Humanity and the Earth, but Not Civilization*

Figure 13: 2nd stage of the septic system project in Bahamas: planting day

Note: reproduced from *Duke's Nicholas School of the Environment* (2010), *Toby Hemenway – How Permaculture Can Save Humanity and the Earth, but Not Civilization*
Afterwards, they linked the septic system of the school to the two concrete lagoons (underneath the soil) so that the waste, effluents of the 100 people studying and working there, after flushing the toilet, would directly go to the lagoons.

Figure 14: 3rd stage of the septic system project in Bahamas: 3 months after

Note: reproduced from Duke’s Nicholas School of the Environment (2010), Toby Hemenway – How Permaculture Can Save Humanity and the Earth, but Not Civilization

The results were amazing. Water, nitrogen and nutrients were pumped into the lagoons on a daily basis thanks to the septic system, and the lagoons were well exposed to sunlight.
Figure 15: 4th stage of the septic system project in Bahamas; 3 years after

Note: reproduced from Duke's Nicholas School of the Environment (2010), Toby Hemenway – How Permaculture Can Save Humanity and the Earth, but Not Civilization

As a result, this school managed to turn useless waste, doomed to be rejected into the sea, into resources incredibly powerful and regenerative. This example further shows that these ecosystems, which agricultural and industrial societies destroyed, can be easily recreated. According to Toby Hemenway, in the past plenty of horticultural societies - such as the Hopewell culture, the ancient Oaxaca, the Nuaulu, etc. - were living a sustainable life and it falls upon us not to go back to the time when they were living but to adapt this sustainable, egalitarian, environmental friendly and earth caring lifestyle.

4.3.2 Permaculture based eco villages

As adapting horticultural societies in our current lifestyle was mentioned, eco villages based on Permaculture can be a concrete application of this adaption. Ecovillages are intentional, traditional or urban communities which goal is to regenerate social and natural environments and become socially, culturally, economically and ecologically sustainable.
There are already around 500 ecovillages in the world today (Global Ecovillage Network), but the thesis will focus on the Permaculture based ecovillages and study one example. O.U.R ecovillage is an ecovillage was developed in 1999 on Vancouver Island, British Columbia (Canada) with the same vision as other ecovillages: create a model demonstration sustainable village community rooted in social, ecological, and economic well being. To bring this ecovillage into existence, a group of 14 people bought a 25-acre of land near a lake and started their community project there. 3 years later, the O.U.R Community Association, a non-for-profit organization, was established and decided to state an inviolable principle: the project must be conducted “by the community, for the community and through the community”. Afterwards, they started to apply Permaculture method to support their sustainability. They built conservation area consisting of one third of the property under a protective covenant. They implemented an organic production farm, as well as an off-grid eco-home cluster of 9 homes (in addition to the existing home currently used). They also provided an allowance for educational activities. Since then, they have been working on various projects in order to further strengthen the community and their sustainability, such as creating an Affordable Eco-Housing Cluster.

Today, a wide number of people belong to the community and participate in various projects. Their organizations are based on the following principles:
- Open, voluntary membership
- “Transparent” administration
- Democratic participation – one member, one vote
- Ethically based practices (in livelihood and lifestyle)

This community managed to build a very ecologically integrated site using Permaculture techniques. For example, in a similar way as the greywater system in Jordan and as the septic system in the Bahamas, they are currently working on a project to pump greywater coming from a house at the top of the hill until gravel pools to filter it. After being filtered, the objective is that water trickles down the hill to irrigate their orchards. Another example is that they produce their own power thanks to solar panels and treat their own waste.

The community is international, people come from all over to belong and participate in this small-scale change. Diversity even comes from people themselves and yet leads them all towards the same goal: living a sustainable and decent lifestyle.
Chapter 5: Conclusion and limitations

5.1 Conclusion

Using an approach that focuses on people’s daily life and people’s environment, this thesis reflected upon the main socio-economical challenges that the world is currently facing and provided a pragmatic and concrete answer to cope with these challenges. The answer is Permaculture. After understanding why Agriculture intrinsically failed to provide an answer due to its unsustainable essence and after understanding why Agriculture is still the most expanded method in the world that intend to come up with solutions while trying to fix itself - to no avail -, the thesis concentrated its efforts on finding an effective, productive and sustainable alternative way to provide the answer that Agriculture failed to provide.

Indeed, on one hand this thesis demonstrated that Permaculture was able to design productive and profitable systems that could help people all around the world to either alleviate poverty or to simply increase their daily life financial comfort. On the other hand the thesis proved that Permaculture was a sustainable alternative on every stage, from the ecological aspect to the durability aspect. Even more, after realizing how uncertain the world of tomorrow would be due to the negative impacts that the environment has suffered from over the past 10,000 years, the thesis reflected upon the term of sustainability and showed that Permaculture had the ability to provide what the world really needs to ensure a safer world to the future generations: the regeneration of our environment.

Finally, this thesis addressed the different ways of possible Permaculture replications. It first evaluated the conditions to reach in order to properly replicate an effective Permaculture system, and in a second time provided some recommendations on how to learn and spread Permaculture among people, as well as some examples of successful Permaculture societies living a sustainable and plain life.
5.2 Limitations and future research

The uniqueness of the thesis lies on the fact that it endeavored to gather knowledge from various authors, surveys, organizations, etc. in order to offer accurate answers regarding different topics. However, this uniqueness also has its own limitations. Indeed, although the issues that were tackled in this thesis are all related to Permaculture and therefore are all related to each other, most of the time each survey, author or expert addressed one issue at a time and demonstrated that Permaculture could provide the adapted solutions. Yet, this thesis did not ascertain the fact that all Permaculture could combine all the answers at the same time and provide a global solution to the socio-environmental problems mentioned in the introduction.

In that context, a future research could be conducted so as to ascertain that Permaculture can provide this global solution. For example, a survey could be realized on a poor population suffering from anger, malnutrition and directly impacted by the pollution of their environment. The survey would thus aim at determining whether a Permaculture project could considerably improve the living conditions of this population.
References


