Use of Permaculture in Water Management for Sustainable Agricultural Development & Water Recycling Process

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Abstract: Water plays a significant role in any agricultural project as well as in domestic usage in different communities surrounding the world. In the twenty-first century, different agricultural, water and wastewater management techniques has been evolved involving lots of energy and resource wasting procedures and those also cause too much investments. But if we can accept a new way of agro-ecological process called permaculture to reduce the waste of energy and resources, we can surely generate a sustainable long term usable accumulation of resources for our household usage and agricultural development of the society in a sustainable manner. There are some principles for permaculture techniques to get the best possible results by reducing, reusing, replacing and recycling the resources around our communities like interaction and observation of surrounding forces, limiting our self-consumptions, establishing relations within the separate systems within a particular system, storing energy in terms of water, bio mass, electricity etc. A creative usage of space is also a part of those permaculture principles. In this paper we have illustrated our discussions by explaining some water management systems with the help of permaculture technique which can be used for sustainable agricultural, habitat project. A detailed discussion is also done about some water management processes using permaculture fundamentals like seepage, firefighting, irrigation, recreation, habitat and aquaculture ponds. Different permaculture waste water recycling techniques for recycling grey and black water like Wetland plant systems, Big plant systems, Eco machine systems, Branch drain system etc. are also discussed in this particular context.

Keywords: permaculture, agriculture, pond, sustainable, energy, recycling, wetland.

I. INTRODUCTION:

Agriculture is the backbone of any society, state or country undoubtedly. Now a days different types of artificial cultivation techniques has been introduced which requires a huge amount of external resources, investment and special care for the execution of the same. For an example, most of the places in India has a monsoon period of 3 to 4 months, the water distribution to cultivable regions are done with the help of precipitation in the form of rain in this period, but for the remaining period of time in a year, the irrigation water is distributed with the help canals from streams, reservoirs, dams etc. which requires an amount of external renewable and nonrenewable resources. Permaculture solves this problem of decrement of renewable resources like water, hydroelectric, biofuel, human resource, and nonrenewable resources like petroleum in the form of petrol , diesel etc. and also protects the soil from adverse effects of inorganic pesticides , insecticides etc. It solves these problems of continuous degradation of natural resources which are incessantly being used in agriculture or irrigation systems and also develops a sustainable habit of agriculture.

II. PERMACULTURE: A SUSTAINABLE PROCESS FOR AGRICULTURE AND LANDSCAPING:

Permaculture means 'Permanent Agriculture' which does not require any resources from externally but creates its own amount of resources to get a sustainable yield. It can also be called 'Permanent Culture'. This is a combination of agro ecological movement and traditional farming process. Permaculture also produces a socio ecological land and water usage habit. It forms ecosystems which are agriculturally productive and gives a sustainable yield.

III. ROLE OF WATER MANAGEMET IN PERMACULTURE DESIGN:

Water is the foundation for permaculture design and is always the first priority for any system. Being a renewable energy, water needs to be treated and reused for the sake of mankind. In a permaculture way of treatment water is to be supplied to the plants and crops through certain procedures in a long term sustainable pattern and also the house hold waste water (mainly sullage) is also treated by using permaculture. In this paper we shall focus on these techniques.

IV. PERMACULTURE WATER MANAGEMENT TECHNIQUES:

There are different permaculture techniques to purify and treatment of water for the development of surrounding community in a sustainable way to get a proper yield and to get reusable fresh waters. Some of them are described below.

1. Permaculture Ponds:

Ponds have great importance in permaculture landscape development process. It is really beneficial to surrounding ecosystem and hydrology of an area. It can also be a disastrous hazard when it is made in a wrong place in wrong climate and the construction is the wrong process. Construction and thought process of different permaculture ponds serving different purposes are described below

A. Seepage Pond:
Seepage ponds in the permaculture landscape retard the water flow within the watershed and allows the water to seep into the ground and form an underground water table. Here water moves through the soil of the bank but it is not held tight. The pond is actually constructed to seep. A pond seeps water if it is not lined or sealed. It also depends on soil type whether there is not enough clay content in the soil or if that soil has not been compacted. Multiple seepage ponds placed throughout the landscape can recharge and rebuild the underground aquifer of the whole area. As a seepage pond has uncompact soil, the embankment itself does not hold back water.so it should not be planned as a structural feature. Seepage ponds are really excellent for restoring springs that can pop up below the pond because of the moving underground water, they can actually sub irrigate crops from underground so the plants are passively watered by the underground seeping pond water.

Fig.3: Seepage pond

B. Irrigation pond:
An irrigation pond collects water and these collection of water is from precipitation in form of rain. This water will be emptied during the growing season to irrigate crops. So irrigation ponds should be sealed to save water in it for a prolonged time. If they can't be sealed by compaction, then they could be lined. Water from an irrigation pond will need to be distributed into an irrigation system. And most commonly people use either a lock pipe going right through the dam wall or a siphon to get the water out of the pond in a controlled way. Now because this is being used for watering crops, a rain fed irrigation pond will be empty by the end of a dry season.

Fig.4: Irrigation Pond

C. Recreation Pond:
It stays full through the summer season for swimming and other household activities and this kind of pond beds have a gradual slope on all sides so people can get access easily and safely with a shallow end for children. It could be lined or unlined according to the needs and soil condition.

Fig.5: Recreation Pond

D. Firefighting pond:
This type of pond remains full for the entire dry season. The water in a fire fighting pond needs to be able to get released from the pond in the event of fire breakouts to some sort of fire containment lines by feeding a fire hose, or pressurized sprinklers. But in

practical it is seen that often in a fire breakouts the electricity goes out, so firefighting ponds need to be designed as gravity feed firefighting system without electricity which means it has to be placed in a higher elevation in the landscape. It is also kept in mind that it should be big enough for a firefighting helicopter to actually land in the forested areas.

Fig.6: Firefighting pond

E. Habitat pond:

This types of ponds have varied depths and edges for lots of different habitant niches. Now it should have natural seasonal fluctuations of the water level so different niches are available during wet and dry seasons. Now from permaculture perspective a lot of different yield can be built in a habitat pond and it can be integrated with the harvest of the aquatic plants, water fowls and fishes.

Fig.7: Habitat Pond

F. Aquaculture pond:

For more intensive fish production aquaculture ponds are introduced. It has more controlled environment where the inflow and the out flow of water are managed to maintain the water level. It is also designed in a way that facilitates the harvest of the species being raised. Aquaculture ponds are mostly found in low lands where water landscapes are transformed into managed production systems. But it can also be in the system as an irrigation source where all the nutrient filled water can be applied to crops.

Fig.7: Aquaculture Pond

Now, it has to be understood that a pond always doesn't fall into one those categories mentioned above. For an example, a recreation pond may be also used as firefighting ponds because both of these ponds require water during the summer. So, a firefighting and recreation can be a same pond.

But a Firefighting and irrigation pond cannot be the same because the earlier is full only in summer but the latter is dried during the summer for irrigation purpose.

2. Recycling waste water using plants:

Plans and biologically active soil can clean dirty water. Ecosystems are being ruined and human heaths are being in danger by poor sanitation and lack of water treatment yet this is just one of the easiest things to fix by permaculture techniques. The basic fundamental is to maximizing contact between raw water and plant roots. There are different types of waste or dirty waters. One is grey water which are slightly dirty water from showers laundry and sinks and another one is black water, which is water from toilets and other dirty wastes. Some of the processes of treating water are described below.

A. <u>Black Water recycling system:</u>

1. Wetland plants:

The root systems of wetland plants retains a huge amount of microorganisms like bacteria and fungi. This massive amount of microorganisms can biodegrade most of the minor pollutants breaking them down into harmless elements. The microorganisms are fed at the root zones. So, from this process, roots becomes a living filter trapping sediment and supplying food for lives. Some wetland plants can absorb heavy metal from water into their tissues.so the goal of any wetland water treatment system is to create maximum amount of contact between dirty water and the roots of a plants species.

Fig.8: Wetland Pond

2. Constructed wetland or Big-plant filter:

The very simplest version of this waste water treatment in this concept is the constructed wetlands. In this, waste water flows into this gravel filled basin that is planted by wetland plant species and it is lined on the bottom with either plastic or cement or something other material so the water does not seep to the ground and stay in the container. The water flows below the gravel level so dirty water is never exposed to air. Baffle walls are made in this system so that water is forced to move up and down through the system ensuring maximum contact with the plant. At the end of the system much cleaner water emerges.

Fig.9: Constructed Wetland

3. Living machine or Eco machine:

These are used to treat black water. In this wetland water treatment the water flows through a series of tanks. So for black water it would start in a septic tank to settle out the solids. Now this is an opportunity to collect bio gas to fuel from the kitchen. But then the water goes into another anaerobic tank, a tank with no oxygen, it helps to further digest the sludge material. So from anaerobic environment we would then radically change he environment of the water and flow it into a tank full of plants where oxygen is actually pumped in so lots of biological activity in water and the water would get to filter through all of those roots of plants. Water flows into the bottom and then reaches the top of each successive tank where oxygen is pumped in and where all types of aquatic plants and animals live. So the water is being forced through a super biologically active filter and is cleaned. Size of the system depends on how much water and how many days of treatment needed.

Fig.10: Living Machine or Eco Machine

B. Grey water recycling systems:

In this system water has to be in contact with biologically active soil. Grey water comes from showers bathroom and laundry. Kitchen and bathroom sinks have more concentrated pollutants and may require grease trap. So they are not really grey water, but black water is biodegradable and bio-compatible cleaning products. Biocompatible product means that will break down biodegradable but are not necessarily good for plant growth like those containing a lot of sodium which is a salt. Bio-compatible products break down into elements that are beneficial for plant growth. There are different grey water systems, one concept of them is discussed below.

Branch drain Grey water system:

Grey water is split from its source into various outlets points and each outlet pipe flows into a bucket with the bottom cut out and holes are drilled into it. The bucket is surrounded wood chips and other coarse mulch and has a tile on top. The total assembly consists underground. Water spills out of the pipe and has a free fall to the bottom of the bucket. There is no contact between the pipe and the soil. Risk of this system is that roots clog the pipes. Water fallen into the chamber then it soaked into the wooden chips which act as a sponge. Around the root chips, perennial plants are planted whose roots find their way into the wood chips sponge and have a continual supply of water. Wood chips buffer the hot water and whole system are becomes super biologically active. At last these wood chips will break down into soil and all that matters clean and feed on the dirt from our shower and as a result lots of perennial plants grow.

Fig.11: Branch drain grey water System

LITERATURE REVIEW:

1. ***Permaculture for agrology, design, movement and worldview. A review*** **by Rafter Sass Ferguson. Sarah Taylor Lovell (2014):**

This paper studied that the term permanent agriculture, from which the word permaculture is derived, has multiple uses. Permanent agriculture is used to contrast sedentary, continuous agriculture with shifting cultivation in discussions of the latter (q.v. Rasul and Thapa 2003; Geist and Lambin 2002). Examination of the British and US literature on farming practices in the early 1900s suggests that the word "permanent" was used in an analogous fashion to the current use of the term sustainable (King 1911; Howard 1940). With the publication of Russell Smith's foundational agroforestry text Tree Crops: A Permanent Agriculture, permanent came to connote agricultural systems incorporating a high proportion of perennial species (Smith 1929). It is this concept for which permaculture is named. Mollison and Holmgren adopted Smith's emphasis on the importance of tree crops for soil stabilization in hillside agriculture, production of fodder, and production of complementary and staple foods for human consumption (Mollison and Holmgren 1978). The portmanteau of "permanent agriculture" was later redefined as "permanent culture" as the scope of permaculture expanded from the design of smallholder agriculture to encompass human settlement more broadly (Mollison 1988).

2. ***Permaculture: Principles and Pathways beyond Sustainability*** **by David Holmgren, 2020:**

This will give readers a deeper and broader idea of the key concepts and values of the permaculture system.
The techniques and concept of permaculture encourage creating resilient living systems that depend on the methods, structures, and patterns that already exist in nature (Krebs & Bach, 2018). It is vital to understand that permaculture does not necessarily follow a

specific set of practices. Some permaculture designers have developed their own techniques and concepts, but the core principles and values remain the same. A common trait, however, in all of these practices and techniques are the twelve major principles of permaculture. These include 1) Observe and Interact, 2) Catch and Store Energy, 3) Obtain a Yield, 4) Apply Self-Regulation and Accept Feedback, 5) Use and Value Renewable Resources and Services, 6) Produce No Waste, 7) Design from Patterns to Details, 8_ Integrate Rather Than Segregate, 9) Use Small and Slow Solutions, 10) Use and Value Diversity, 11) Use Edges and Value the Marginal, and 12) Creatively Use and Respond to Change (Veteto & Lockyer, 2008). Permaculture's founders, Bill Mollison and David Holmgren, shared concerns about the threats of excessive resource consumption, energy scarcity, and resource-intensive agricultural systems. They pulled on numerous sources and incorporated them with the ideas of our ever-advancing and adapting pre-industrial societies, developing a numerous sources and incorporated them with the ideas of our ever-advancing and adapting pre-industrial societies, developing an ecosystem theory and designs that were most applicable for the current environment using these 12 core principles. These principles offer a set of frameworks for people to design nature-friendly, sustainable land use and communities that stays within the ecological boundaries of land use, species, and the exchange of energy within them (Holmgren, 2020). Ecological boundaries are zones, in this case farms, in which a system of interaction between various entities such as soil, organisms living in the soil along with a diverse group of plants exchange energy amongst themselves to create a sustainable ecosystem.

3. ***Water in Permaculture*** **by Bill Mollison. Pamphlet XI in the Permaculture Design Course Series Edited from Transcript of the Permaculture Design Course, The Rural Education Center, Wilton NH USA, 1981:**

According to this pamphlet, Pond edges are good blueberry areas. Mints are invasive, but very productive. Another purpose for the pond might be to grow mints, particularly black mint. You don't need many acres of that. Two or three could bring you $70,000. You distil mint to menthol. It is good to grow mint if you are dairying and have dairy outwash. From that, you get powerful blooms of mint. So you might try a mint marsh for that black peppermint and do simple steam distillations. Mint is such a strong growing plant that it quickly exhausts even ponds. It will get pretty woody after a few years. In cold climates, it has a rest period, and you can re-manure. You can put it on edges; but because it is laterally invasive, I would put a couple of bushes on either side of where I was going to put mint--dense bushes to keep it in its little patch. A good place for bamboo is back from your ponds. They look great.

CONCLUSION:

The following conclusions can be made from the above discussion

1. Permaculture techniques solves the problems of continuous degradation of natural resources which are incessantly being used in agriculture or irrigation systems and also develops a sustainable habit of agriculture.
2. Permaculture leads us to the direction to live simply by limiting our consumptions and emissions with a great responsibility to the earth and people. It also provide us lessons from our mistakes, and opportunities to select better future plans for a better landscape.
3. Permaculture Ponds have great importance in permaculture landscape development process. It is really beneficial to surrounding ecosystem and hydrology of an area. It can also be a disastrous hazard when it is made in a wrong place in wrong climate and the construction is the wrong process.
4. Treatment for grey water and black water can be done by simple permaculture methods using plant roots or wooden chips.
5. Different Permaculture ponds can be used with the following attributes

Table 1

Serial No.	Type of Pond	Attributes
1.	Seepage pond	• Soil seeps always • Uncompact and unlined • Embankment is unstable
2.	Irrigation pond	• Emptied during growing season • Lined or compacted
3.	Recreation Pond	• Stays full throughout summer • Gradual slope
4.	Firefighting pond	• Stays full throughout summer • High volume non-electric release • High landscape position
5.	Habitat Pond	• Varied depths and edges • Seasonal fluctuation
6	Aquaculture pond	• Controlled inflow and outflow • Designed for harvesting

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