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Permaculture

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Abstract

Permaculture is an international grassroots network founded in Australia in the late 1970s that focuses on the sustainable design of human settlement. This decentralized and little institutionalized movement disseminates a distinct worldview, design system, and set of associated practices. Permaculture's central concept is that humanity can reduce or replace energy and pollution-intensive industrial technologies, especially in agriculture, through intensive use of biological resources and thoughtful, holistic, design, patterned after natural ecosystems. To create autonomous, resilient, and equitable living spaces permaculture proposes pragmatic methodological principles informed by scientific ecology, traditional indigenous knowledge, observation, and experimentation. In the design of farming systems, permaculturists promote complex multi-strata polycultures involving perennial plants, crop-animal integration, high levels of habitat diversity, whole-landscape water management, and sustainable on-site energy production. Beyond scientifically-informed ecological design, permaculture encourages practitioners to develop emotional and subjective links with the earth, and develop their imagination and creativity as valuable parts of the design process. The originality and specificity of permaculture are discussed, along with critics, controversies and research perspectives.

Keywords

Agroecology; Bottom-up approach; Energy; Environmentalism; Farm design; Holistic design; Indigenous knowledge; Organic farming; Self-sufficiency; Social movement; Sustainable agriculture; System thinking; Transition

Glossary

Agroecosystem: the basic unit of study in agroecology that is defined as a spatially and functionally coherent unit of agricultural activity, which includes biophysical (soil, climate, plants, animals) and social components (human practices, values, objectives, organizations) and their interaction.

Agroforestry: land use management system in which trees or shrubs are grown around or among crops or pastureland.

Emergy: is a methodology which aggregates all different forms of energy and resources (e.g. sunlight, water, fossil fuels, minerals, etc.) used in the work processes that generate a product or service).

Food forest: polyculture mimicking forest ecology with multiple plant layers (annual plants, shrubs, trees, and liana) which produce a diversity of edible produce.

Holistic: refers to a global thinking or design approach which aims to integrate all dimensions of a situation (which can involve subjective and objective aspects) rather than analyzing only one aspect.

Intercropping: growing different plant species together on the same plot at the same time.

Modern/pre-modern/post-modern: “Modern” refers to a philosophical movement developed in Europe since the 17th century relying on the idea that mastering the material world through rational knowledge will guarantee human progress and emancipation from nature, which is perceived as distinct from humans. “Pre-modern” refers to traditional worldviews which were born before modernism and where human beings are often seen as part of the natural world. “Post-modern” refers to a thinking tendency which criticizes the modern beliefs around progress and in which all assumptions are open to question. According to post-modern thinkers, elements from different systems and traditions can be combined without regard for any fixed aesthetic or tradition.

Sylvopastoralism: land use management system in which animals graze in habitats where trees are present. Animals can feed partially on these trees (fruit fallen on the ground) and benefit from the microclimate they create (shadow, temperature, protection against wind).

1 Brief overview of permaculture

Permaculture is an international grassroots network focused on the sustainable design of human settlement, both in rural and urban areas although it was initially developed in a rural setting. Permaculture's central concept is that humanity can reduce or replace energy and pollution-intensive industrial technologies, especially in agriculture, through intensive use of biological resources and thoughtful, holistic, design, patterned after nature ecosystems (eco-mimicry). Despite a relatively high public profile and broad international distribution, until recently permaculture has received little scholarly attention.

The definition of permaculture varies among sources and expands over time. In the founding text, permaculture's originators define it as "an integrated, evolving system of perennial or self-perpetuating plant and animal species useful to man" (Mollison and Holmgren, 1978). By 2002 Holmgren defined permaculture more broadly, encompassing broader issues of human settlement while maintaining an agricultural focus: "Consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fiber and energy for provision of local needs" (Holmgren, 2002). Recent scholarship has identified four levels or components within permaculture presented in Figure 1 (each of which may be referred to by the term): the international movement, the worldview carried by and disseminated by the movement, the design system, and the set of associated practices (Ferguson and Lovell, 2014). We will introduce each in turn.

1.1 Worldview

Key elements of the permaculture worldview include a theory about human–environment relations, a populist orientation to practice, and a model of social change. The permaculture literature highlights the positive role of humans in the landscape, as ecosystem managers. This perspective is expressed through a literature-wide insistence on the need for holistic planning and design and an optimistic assessment of what these styles of management can achieve. This perspective on human–environment relations cuts against the grain of the dualistic worldviews of both growth-oriented development and preservation-oriented conservation, each of which describe a fundamental conflict between the needs of society and those of nature. At the core of the permaculture worldview is the idea that—with the application of ecologically informed holistic planning and design—humans can meet their needs while increasing ecosystem health.

1.2 Design

The permaculture design system utilizes ecological and systems-thinking principles, and spatial reasoning strategies, which are used to analyze site conditions, select practices, and integrate them with site conditions and land use goals. The most distinctive aspects of the permaculture orientation toward agroecosystem design are its emphases on (1) site specificity, including attention to microclimate; (2)

interaction between components at multiple scales, from field-scale polycultures to agroecosystem-scale land use diversity; and (3) spatial configuration as a key driver of multiple functions.

1.3 Practice

Land use in permaculture shares much with agroecology, agroforestry, and traditional and indigenous land use. Since the techniques associated with permaculture rarely originate from within the movement itself, the practical stratum is better regarded as a best practices framework than a bundle of techniques. Best practices in permaculture are evaluated by two broad criteria of ecosystem mimicry and system optimization. Ecosystem mimicry regards the structure and function of unmanaged ecosystems as models and attempts to create highly productive systems with analogous structure and function using species that produce yields for human use. System optimization does not refer to a model ecosystem, but seeks to identify strategic points of leverage where minimal intervention may enhance performance of desired functions beyond that of naturally occurring systems. Together, these criteria outline an implicit conceptual framework for the evaluation of practices in the permaculture movement.

1.4 Movement

The permaculture movement communicates the worldview and disseminates elements of practice and design through networks of practitioners and small institutes. The growth and dissemination of permaculture is built on two basic patterns: a widely dispersed network of “itinerant teachers” and local/regional organizing based around “bioregional” cultures and the development of alternative economic and social institutions. The permaculture movement today consists of a loosely affiliated network of individuals and projects, connected through permaculture courses and workshops, online forums, and local projects, as well as through and regional, national, and international convergences. Groups generally display a low level of institutionalization, and projects encompass a wide variety of functions, commonly including community gardens, campus greening initiatives, educational efforts, and less commonly, demonstration and/or research sites, periodicals, and farming-focused education and support efforts.

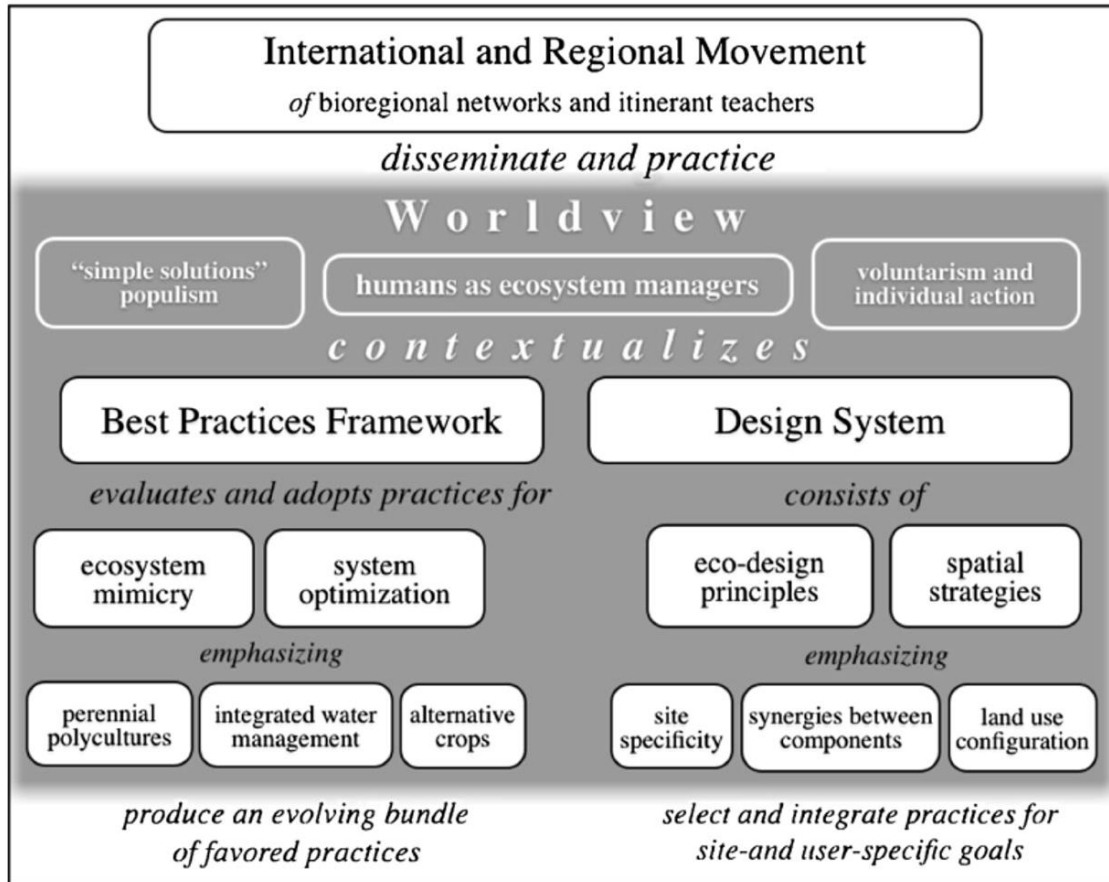


Figure 1: Stratified definition of permaculture (Ferguson and Lovell, 2014).

2 Conceptual foundation and dissemination

2.1 The genesis of permaculture

“To many of us who experienced the ferment of the late 1960s, there seemed to be no positive direction forward, although almost everybody could define those aspects of the global society that they rejected. These included military adventurism, the bomb, ruthless land exploitation, the arrogance of polluters and a general insensitivity to human needs. An unethical world could waste more on killing people than on earthcare or on helping people.”

This quotation is from Bill Mollison, creator of permaculture and co-author with David Holmgren of the founding book "Permaculture one" published in 1978. Permaculture is anchored in the multifaceted critical movements that emerged in the late 1960s with the North American

counterculture and the birth of human ecology. These movements relied on emerging critiques of the resource-intensive materialism of consumer society, of sexism and racism at home, and militarism, imperialism, and unequal development leaving third world countries behind. In this context, social movements emerged with radical propositions for new ways of organizing society that could act as an alternative to a socio-economic system rooted in overexploitation of natural resources and the exponential growth of energy consumption, consumerist individualism, and the political and moral norms that of the economic elites. While some of these movements engaged in fairly "classical" political struggle, permaculture was among those that spurned conventional movement politics to work directly on concrete interventions, practical solutions for building an "other world," one whose key-word would be self-sufficiency.

The "back to the land" projects that multiplied in the 1970s, and spread from Australia to Europe via California, are part of this latter logic and set the stage for the emergence of permaculture. Faced with the hegemony of the dominant socio-economic model, their bearers sought to "withdraw from the world" by settling in isolated and / or abandoned by industrial development areas, in hopes of using the practice of traditional agriculture to rebuild a pre-modern link with nature. They acknowledged that nature could not entirely be grasped by rationality and that a (re)-developing a subjective and respectful relationship to nature was critical. The romantic or naturalist inspiration (e.g. Thoreau's *Walden*) of this movement was obvious, as was its apocalyptic dimension: this world, which in its irrepressible greed seemed to want to destroy its natural environment irremediably, would end before long. Those who have built and preserved havens based on the renunciation of a utilitarian and dominating vision of nature, would be the guarantors of the salvation of humanity.

Permaculture's founders and early adopters articulated a set values and principles in parallel with identifiable currents of ecological thought, based on the belief that industrial societies based on fossil fuel threaten the survival of human beings, on the rejection of anthropocentrism, and on a holistic worldview that opposes utilitarian reductionism. These positions were close to James Lovelock's Gaia Hypothesis or Deep Ecology (Naes, 1973). The relationship with deep ecology is particularly evident in Bill Mollison's later remarks (AtKisson, 1991): "Permaculture exhorts a total co-operation with every other and every other thing, animate and inanimate". For the founders of permaculture, this cooperation between humans and nonhumans is the basis of a global transformation of societies respecting three fundamental ethical principles: caring for the Earth; caring for people; and establishing limits on consumption and redistributing surplus (Mollison and Holmgren, 1978). They believe that this transformation must start from the initiatives of individuals anxious to act by and for themselves, re-building communities as they reconstruct human-environment relationships – gradually and from the bottom up. This logic of horizontal and bottom-up construction of a new society suggests affinities between permaculture and the non-violent and ecological component of the anarchist movement of the end of the 19th century, of which Elisée Reclus, Geographer and French anarchist activist, is one of the most prominent figures, and which would be renewed in the USA in the latter decades of the 20th century with activist thinkers like as Murray Bookchin.

In the same interview cited above, Bill Mollison, however, refutes this connection. He rejects any form of power relationship or coercion as inseparable, from his point of view, from political action, even anarchist, and considers that the multiplication of individual initiatives cooperating with each other is enough to change the world. If permaculture is claimed to be subversive, this subversion does not involve political struggle, but rather a gradual dissemination of a belief translated into located concrete experiences: the construction of a sustainable world requires the reincorporation of humans into ecosystems natural. Permaculture proposes principles, conceptual tools that can guide the action of each one in this direction. It is thus defined as an "aid to the decision-making ethic " (Holmgren, 2002). In this perspective, the expansion of the permaculture network may require training in principles and tools, but this training is more about awakening to another way of being in the world than the acquisition of established technical knowledge.

2.2 Permaculture, a pragmatic ecology for self-sufficiency

Permaculture proposes pragmatic methodological principles to create autonomous, resilient, and equitable living spaces. For Bill Mollison and David Holmgren, the fundamental flaw of industrial societies lies in the inextinguishable thirst for energy that structures their development and precludes any long term sustainability. To escape from this addiction, they postulate that permaculture design must be inspired by the structure and function of natural ecosystems. This perspective is directly inspired by the works of scientific ecology, particularly those of Eugene Odum, and even more by the approach of ecological thermodynamics and environmental accounting proposed by Howard T. Odum (1971, 1995). These works are one of the main references cited by David Holmgren (2002) in "Permaculture: Principles and Pathways beyond Sustainability", a book in which he resumes and deepens the principles of design defined in "Permaculture One" (Mollison and Holmgren, 1978).

In this line, permaculture interprets the dynamics of natural ecosystems as an accumulation of energy that drives ecosystems towards "closed loop" cycles of matter, in which less and less materials are lost from the ecosystem over time. Inspired by these natural processes, the design of self-sufficient human settlements must emulate ecosystems by maximizing the interrelations and synergies between the various human and non-human components and trigger a dynamic of aggradation. Perennial elements, especially trees and soils, play an essential role in this process by storing energy and carbon. For permaculturists, biodiversity and agrobiodiversity are valued for the functional redundancies they create and their beneficial effect on resilience, e.g. the provision of high-energy foods should be provided by cereal crops as well as root vegetables or trees producing fruits rich in starch. The same element must also fulfill several functions, e.g. a legume supplies of protein and improves the soil fertility; a pond stores water and helps regulate the microclimate. Design must project itself into the future, the landscape it draws is an evolutionary structure and this evolution must be considered as much as possible at the outset. Thus, by planting trees, one must imagine how they will grow and what will be the consequences for herbaceous plants at their feet. The elements to cover human needs should be as much as possible found or produced within the system, and efforts should be made to

minimize these needs. Self-sufficiency is thus an objective as much as a means of the project. Under these conditions, human settlements can be part of a process of global ecological and human improvement, in which the needs for inputs of energy and materials as well as human labor diminish gradually.

Holmgren (2002) has defined twelve principles of permaculture design. These principles form the basis of a reflective design process geared toward outcomes that align with the principles described above and the underlying ethical principles. These principles are: (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, (12) creatively use and respond to change. Each principle is individually described and discussed in the permaculture literature with concrete design illustrations. For example, principle (6) highlights that waste production should be as low as possible and that their recycling must be systematized, as in nature where the concept of waste does not exist since elements are used and recirculated locally. Permaculture books presents simple solutions to apply this principle, such as breeding poultry to transform kitchen waste into eggs, meat and manure. The implementation and combination of all principles implies and demands a systemic vision. For Mollison and Holmgren this vision cannot be achieved through exhaustive analytical knowledge of the ecosystem, its components, and its mechanisms - which is in any case unattainable. Rather, it must be the result of a holistic, sensitive, and critical understanding of the place, for which scientific knowledge is merely one form of support amongst other aesthetic, spiritual, or moral considerations.

This holistic reading of space implies that permacultural design combines an objective perspective, based on empirical and/or scientific knowledge, and a subjective perspective, reflecting personal sensitivity. To achieve this difficult synthesis, Bill Mollison was inspired by the Australian aborigines, with whom he had worked for many years during his academic career in Tasmania (Mollison, 1988). Aboriginal thought is organized around the central concept of Dreamtime, the original cosmological dimension in which the different spirits and ancestors physically shaped the world, physically impregnating it with the organizing patterns that underlie the "just order" of things. In order to understand these patterns and the relationships between them, the observation of nature is central. It not only involves the intellect but also the intuition and the humble and silent perception of the world called *dadirri* by the aborigines. As in aboriginal thought, permaculture invites both objective and sensitive observation of landscapes, enabling us to identify the patterns and interfaces that structure it and on which design will have to rely. The purpose of this design process is not only utilitarian. It is the conjunction of utilitarian, spiritual, ethical, and moral dimensions that makes this space a "place for life", inhabited more than occupied, shared with other living species.

2.3 Presence of permaculture in the world

From the foundational work articulated by Mollison and Holmgren in the late 1970s, permaculture concepts, worldview and practices have been spread through a quickly growing and largely decentralized, informal movement (Ferguson and Lovell, 2015). Given its Australian origin, permaculture first was disseminated in the 1980s in industrialized English speaking countries (mainly Australia, United States and Britain) through the development of generally small-scale projects designed to increase individual, family or community self-sufficiency as a response to the growing environmentalist concerns, especially about peak oil. Most of these initiatives aimed to make people “responsible and productive citizens” instead of being consumers dependent on fossil fuel driven economy and production. Since the 1990s, permaculture was brought to southern countries mainly by northern NGOs and activists as a framework for enhancing the sustainable development and resilience of marginalized communities facing the issues of limited resources, climatic uncertainty, and social inequality.

Permaculture projects are now present in more than 120 countries on all continents around 2500 permaculture projects were referenced in 2017 (international permaculture website permacultureglobal.org). The number of permaculture projects led by NGOs or civil associations is estimated around 4000 including 140 humanitarian projects. The Permaculture Design Certificate (PDC) is considered by many permaculturists as a mandatory “entrance point” to permaculture. The PDC can be obtained after a collective and participatory training session intended to provide participants with a global view of the permaculture framework and the design tools which would help them to further carry out their own experimentations. The collective dimension of PDC training aims to create strong links between students which can lead to future collaborations, exchanges of know-how, feedbacks on putting permaculture into practice and contributes to the vitality of interactions between practitioners. The number of people with PDC is estimated from 100 000 to 500 000. Given the informal nature of the global permaculture movement, it is impossible to estimate the number of practitioners implementing permaculture approaches or inspired by permaculture with no certification. This number is likely to be high especially in southern countries where development and humanitarian oriented permaculture training and workshops are organized in rural communities outside the framework of the PDC.

Regionally, permaculture initiatives and projects are sometimes promoted and connected through structured networks and local organizations. In line with its worldview favoring grassroots and small scale initiatives, permaculture is globally far less institutionalized and organized than other social and environmental movements. Regional and international gatherings, like the International Permaculture Convergence happening every second year in a different country, help creating links between practitioners and maintaining the feeling of collective belonging to the permaculture community.

Itinerant teachers, including Mollison and Holmgren, have played a major role in the rapid dissemination of permaculture, providing PDCs and other training all around the world and writing books. Based on their notable differences in personality and approach (they stopped working together shortly after the publication of *Permaculture One*), they have promulgated their visions of permaculture

with different emphases and in different directions, in turn encouraging subsequent generations of permaculturists to develop new and distinct areas of focus. For example, Geoff Lawton (<http://www.geofflawtononline.com/>) is well known for having developed design practices related to water conservation and farming in hyper-arid areas, based on his experience of “Greening the desert” in Jordan. Rosemary Morrow (2010) has achieved international recognition for developing and teaching permaculture approaches adapted to poor and post-war countries in Asia, Africa and Eastern Europe. She strongly focuses on non-violence methods and the design of highly nutritional gardens easy to maintain with local resources while providing a high diversity of nutrients and vitamins to prevent diseases linked to extreme poverty conditions. Building on the successful dynamic first developed in the British town Totnes, Rob Hopkins (2008) has promoted collective approaches to design and manage solidary human settlements adapted to a post-petrol society. Such processes are supported by a set of facilitating tools and principles to release the “genius of the community” and find creative alternatives to petrol which often result in rethinking globally various dimensions of human communities such as education, health, food, habitat, transportation, economic exchanges (local money) etc. (Aiken, 2017). Hopkins’ approach inspired from permaculture has given birth in 2006 to the rapidly growing Transition Network (<https://transitionnetwork.org>). In 2017, this network regrouped more than 500 initiatives committed to the post-petrol transition and willing to exchange on their experiences at different scales: neighborhoods, villages, towns, cities and even regions, in more than 50 countries (mainly industrialized countries).

3 Specificity and originality of permaculture

3.1 Agricultural implementation of permaculture

In the field of agricultural production, the practical implementation of permaculture shares many similarities with other alternative farming approaches such as organic farming, biodynamic farming, agroforestry or agroecology. All these movements have historically promoted the development of resource-efficient and pesticide-free agroecosystems favoring local nutrient cycling (e.g. using compost, green or animal manure) and favoring biological regulation by maintaining a high level of biodiversity to keep plants and animals healthy. Permaculture echoes agroecology and agroforestry for the central place given to spatial association of species (combination of trees, animals, crops; intercropping; diversified landscapes). As organic and biodynamic farming, permaculture attaches a great attention to soil fertility. Permaculture has much in common with traditional organic farming, agroecology, and biodynamic farming, in the sense that all these approaches promote a harmonious and respectful integration of human beings in nature. However, historically biodynamic farming stems from spiritual preoccupations (theosophy), organic farming and agroecology are more connected to peasant’s movements collectively and politically fighting for their sovereignty, whereas permaculture

was born to support individual and community-scale self-sufficiency initiatives in preparation for a post-petrol world.

Compared to other alternative farming approaches, one major specificity of permaculture is the central emphasis on the conscious global design of agroecosystems rather than focusing on specific techniques. In the design process, the different functions expected from the agroecosystem (e.g. “providing food for chickens”, “keeping water available in summer”, “mitigating the dominant winds”, “fertilizing the garden”) are listed. Different elements are integrated in the design (e.g. “a vegetables garden”, “a pond”, “a hedge”, “poultry”) ensuring that every function is fulfilled by various elements and every element fulfills various functions, thereby mimicking the functional redundancy of natural ecosystems and fostering system resilience. The different elements are combined and spatially organized using a set of design tools (e.g. checklist of principles, mapping of site specificities, chart of interactions) in order to maximize the positive interactions between elements, benefit from the specific opportunities, and to mitigate the constraints of the site. Influenced by the work of H.T Odum, plant and animal species are regarded as distinctive but interchangeable system components which should be selected from a global pool based on functional criteria without regard to their place of origin. The conscious design of permaculture landscapes aims to mimic natural ecosystems and maximize positive interactions within the agroecosystem (e.g. biological regulations, creation of favorable microclimates). This global approach echoes “ecological engineering” by its systemic dimension and the importance given to design to create sustainable ecosystems (Mitsch and Jørgensen, 2003). However, ecological engineering, mainly implemented for the restoration of natural areas, is based on “self-design” (or self-organization) which tends to let ecosystems organize themselves as naturally as possible. Although permaculture design is flexible and values creative response to change during the management phase, the evolution of the system should be planned as much as is to maximize the chances that that human goals for the productive ecosystem (food, fiber) will be met.

Permaculturists tend to implement complex multi-strata polycultures, intercropping, agroforestry (e.g. food forests), crop-animal integration (e.g. silvopastoralism), and to promote a high diversity of habitats, integrating landscape features such as ponds and hedges. Soil tillage is often limited and soil is constantly covered by plants or organic mulch to favor the development of soil organisms that will work for humans and structure the soil (e.g. earthworms), store carbon and limit erosion. Trees and perennial plants often play a key role as they are considered energy accumulators (storing carbon and making nutrients available for other species).

Perennial plants and trees are prioritized with the aim of reducing human labor (i.e. annual planting), together with an ergonomic zoning of the site where production areas are spatially organized according to the degree of human intervention they require. Permaculture landscape planning organizes space and elements into five areas with different levels of intensification: from “zone 1” where human intervention is the highest and most frequent (e.g. vegetable garden) to “zone 5” which is a natural area left deliberately unmanaged (Mollison, 1988). Zone 5 is seen both as a reservoir of biodiversity and a place where practitioners can observe “how local nature works”, which can provide inspiration

and design ideas for the rest of the site. In this way permaculture design integrates the spatial logics of “land sparing” (separating intensive production zones and natural areas) and “land sharing” (managing areas with reduced intensification to preserve biodiversity in productive areas) (Fischer et al., 2014). However, permaculture goes beyond this distinction as even the most productive areas are designed to maximize biodiversity as a way to maintain resilient and productive ecosystems, echoing the logic of “ecological intensification” (Bommarco et al., 2013).

As the edges between zones are regarded as being spaces of maximal diversity and interaction between species, permaculturists often maximize edge by designing cultivated areas with curved and undulated shapes rather than straight lines. The use of earthworks, dams and swales for water harvesting and control is central, as is the development of renewable sources of energy on the production site (e.g. solar panels, passive solar buildings, wind turbines, biomass and hydroelectric devices).

3.2 Rethinking modernity and empowering people beyond optimizing ecosystems

In providing conceptual tools and design methods to observe and mimic patterns from complex natural ecosystems with the goal of designing resource efficient human settlement, permaculture could be seen as a modern, biologically-inspired approach to system optimization. In this way permaculture could be read as replicating the rationalist, instrumental relationship with nature that characterizes modernity and the industrialized world. In industrialized countries, modernity has become politically dominant in the 19th century and has spread all over the world with western culture and globalization. A growing number of philosophers and scientists argue that modern thinking, which consider nature just as an objective pool of resources which have to be rationally exploited, may be one of the major causes of the environmental issues that humanity is facing now. Permaculture departs from this tradition in several ways. Inspired by what Holmgren calls “traditional cultures of place” – pre-modern cultures where human beings have developed through time ecological knowledge and sensibility adapted to their specific environment – permaculture encourages practitioners to develop emotional and subjective links with the earth that will foster a feeling of responsibility toward the places where they live (2002).

Permaculturists also acknowledge that diversified ecosystems are complex, will unlikely ever be fully understood rationally, and that global environmental crises call for rapid human action despite limited ecological knowledge available. This is why permaculture encourages practitioners to develop skills and senses such as imagination and creativity in addition to rational, instrumental skills of observation, analysis, and system optimization. In this sense, permaculture has sometimes been described as a post-modern approach where elements from different systems and traditions are hybridized without regard for any fixed aesthetic or tradition, and where the importance of rational knowledge is consciously balanced and integrated with more subjective and relational human capacities.

Post-modern or not, it is clear that permaculture questions the modern and industrial world as we know it. It invites practitioners to become creative “new indigenes” while developing knowledge, interaction capacity with their local environment and community, and useful skills to become more self-sufficient in order to move from their status of dependent and demanding consumers to interdependent and responsible producers (Holmgren, 2002). This empowerment of individuals and communities is aimed both as a way to decrease the dominance of industrial systems today, and to prepare and for survival in a future post-industrial era with no access to fossil resources.

4 Criticism, controversies and research perspectives

4.1 A tendency towards oversimplification and overreaching

Permaculture has a troubled relationship with ecological science. Permaculture has received criticism for overreaching and oversimplifying claims. This tendency is encapsulated in the notion that humanity already possesses all the knowledge necessary to replace current land use with permaculture systems, across all social and ecological contexts, and that the process of redesigning is itself straightforward. In the absence of reliable data to support these proposals, permaculturists often rely on limited case studies and sweeping extrapolation from ecological principles. Most permaculture texts do not refer to contemporary scientific research. Much documentation available is found in grey literature which is difficult to access or verify. The effects of this isolation include the lack of reference to contemporary developments in relevant science, the accompanying persistence of idiosyncratic or misleading terminology, and the potential for influence of pseudo-scientific theories. The permaculture literature assigns the blame for this isolation on the inability of scientists and institutions to comprehend or appreciate the radical proposals put forth by permaculture. Permaculture opponents argue that permaculture practitioners may be reluctant to get involved in systematic scientific research whose results could challenge or temper their idealistic claims.

One common example of oversimplification is the conflation of net primary production with agricultural productivity. One point where this becomes apparent is in permaculture’s advocacy for perennial production systems - justifying this proposal, in part, based on the high photosynthetic surface area and correspondingly high primary productivity of these systems. While forest ecosystems are among the highest in NPP, perennial plants allocate a higher percentage of photosynthetic activity to structure than annuals and therefore have a slimmer margin for export as edible tissue, rendering the comparison of potential yields a complex empirical question rather than a simple maxim. Another example is the claim that complex shapes in fields, garden beds, and ponds will increase productivity – what is called the “edge effect.” This claim was originally based on the permaculture principle of edge effects that was itself extrapolated from the ecological characteristics of ecotones and anecdotal

reports of edge effects in grain cropping systems. While edge effects are real, their strength, reliability, and practical applicability across widely varying contexts (i.e. from cereal fields to intensive garden beds to pond edges) is not supported by scientific evidence and is likely exaggerated. Increased biological productivity may not translate to increased harvestable yields, and the benefits of an increase in harvestable yields may be swamped by the increased labor required by complex edges.

4.2 Limited political impact and scaling-up

The simple solutions populism of permaculture suggests that the best responses to global crises can be implemented immediately with readily accessible materials and skills. This worldview is reflected in a model of change that mostly spurns systematic engagement with existing institutions in favor of direct intervention into the means of subsistence, reintegrating production and resource management under the stewardship of local individuals and communities. The flat network structure that accompanies this mode of action appears to be a conscious strategy to avoid the twin dangers of co-optation and outright suppression to which grassroots efforts are vulnerable. This model has met with some success, as evidenced by its international distribution and positive influence on urban land use, horticultural and agricultural practices, and other sustainability-relevant behaviors across contexts.

The evident successes of the permaculture network are balanced by problematic assumptions and implications that evoke the hazards of insularity, exclusivity, particularity, and scale mismatch to which grassroots networks are prone. The permaculture movement displays significantly less organization and institutionalization than other international agroecological movements, e.g., La Via Campesina, Campesino à Campesino, or International Federation of Agricultural Producers. This lack makes the coordination of action beyond the immediate community scale difficult or impossible and thus limits the potential for mobilization of political support for diversified farmers. Low levels of institutionalization may also constrain capacity for program development, systematic tracking of outcomes, and engagement with potential allies. Recent research suggests that the permaculture network in the UK is vulnerable to insularity, and thereby leads to a lack of capacity to influence relevant institutions and communities.

Permaculture's optimistic focus on holistic and positive action, on personal responsibility, and on the simplicity of needed solutions, is empowering for participants and is likely a significant driver of the spread of the movement. However, the portrayal of agroecological transition as something that individuals can contribute to, using simple techniques at home, is a double-edged sword. While prioritizing the perspectives and capacities of land users is important, it may also run the risk of depoliticizing aspects of agroecological transition that are fundamentally political, and trivializing the complexity of socioecological processes and struggles.

4.3 Permaculture, traditions and neo-colonialism

Permaculture has also received criticism on socio-political grounds. Critics have observed that permaculture was brought to developing countries from “knowing westerners” visiting poor

communities in a similar way to humanitarian action and green revolution packages which may be seen as a form of neo-colonialism. However, scientific literature has highlighted that the principles of permaculture teaching based on individual observations and collective learning favored the empowerment of poor communities while not providing ready to use solutions designed by westerners but providing people conceptual and organizational tools to design creatively themselves their own solutions (Conrad, 2014). The little data available on permaculture in international development suggests a mixed record: sometimes implemented in a responsive and accountable fashion, and sometimes with a neo-colonial savior mentality.

The movement has received criticism for a failure to acknowledge the similarity of permaculture's proposals to indigenous cultures of land use and for re-packaging indigenous land management practices as an innovation originating within permaculture. The extensive permaculture literature on small scale multi-strata agroforestry uses the terms "food forest" and "edible forest garden" but rarely makes reference to the pan-tropical homegarden traditions that forms the conceptual basis for these practices and provide the vast majority of their existing land user base. Indeed, home gardens in tropical areas — from Javanese homegardens to the Creole gardens in the West Indies — traditionally involve multipurpose trees and shrubs in intimate association with annual, perennial agricultural crops and livestock, (Fernandes and Nair, 1986). Similarly, the integration of aquaculture in ponds, crops and livestock often practiced by permaculturists is drawn from traditional production systems in Asia (Prein, 2002). The founders of permaculture, Mollison and Holmgren, consider that if these sources are clearly acknowledged and respected, their use in permaculture contributes to the preservation of this rich heritage and to the recognition that westerners seeking to create sustainable human settlements have much to learn from indigenous (Mollison, 1988; Holmgren, 2002). In the same way many permaculturists seek to incorporate plant and animal species according to their functions and not to their origin, Mollison and Holmgren consider that elements of traditional knowledge from the global "indigenous pool" can be detached from their original paradigm and combined to other elements and sources of information such as scientific knowledge "to create new local cultures with hybrid vigor" (Holmgren, 2002). Critical social studies have argued that this process could be considered cultural appropriation of traditional knowledge by "university-educated white males from a wealthy country" (Conrad, 2014). Nevertheless, in many developing countries, poor rural communities have adopted permaculture as a way to reassert the value and authority of indigenous knowledge and reclaim the rights to farm "as their ancestors did" (Conrad; Millner). Some "local traditions" have been reimagined and hybridized with useful practices, principles, and scientific concepts coming from other parts of the world. In this regard, some studies have considered that permaculture has been appropriated by poor communities to create new cultural identities adapted to the modern world based on traditional ecological knowledge (Millner, 2016). Conflict on the topic of the use of indigenous knowledge in permaculture, and more generally in ecological engineering, continue and can be a fascinating research field for anthropological and sustainability studies (Veteto and Lockyer, 2008).

4.4 A need for research about the agricultural efficiency of permaculture

Despite permaculture's origins within academia, Mollison's and Holmgren's work received very little academic attention when published in the late 1970s and 1980s. Academic reactions were mainly negative because the disciplinary specialization at that time left academics ill-prepared for the holistic approach that permaculture offered (Veteto and Lockyer, 2008). Permaculture embraces many themes and has been given many often very vague definitions, which may have caused confusion and limited systematic discussion. Its idealistic aspects have been perceived as impractical by many scholars (Ferguson and Lovell, 2014). Most private companies do not have financial interest to research and disseminate it. Since the 1980s, permaculture books and articles have mainly been written by practitioners outside academia benefiting from the high interest and enthusiasm that permaculture received from civil society. Over the decades following permaculture's emergence, sporadic academic papers have dealt with permaculture in different fields such social and behavioral sciences, architecture, education. These papers were mainly descriptive of permaculture principles and applications, with little critical analysis - though this has changed in recent years.

Very little scholarly work was carried out on permaculture from an ecological or a life science perspective based on quantitative data, especially in the agricultural field which was permaculture first priority and historic starting point. Permaculture claims to provide tools and methods to design resilient, productive resource and labor efficient farming systems based on a high level of biodiversity and beneficial ecological interactions. These assumptions remain little documented and controversial. In this regard, the most significant studies have been led for doctoral dissertations. In industrialized countries (the USA and France), they have shown that the productivity and economic returns to labor of commercial permaculture farms could benefit from high level of cultivated diversity, crop/animal integration and be economically successful even with low levels of fuel consuming motorization (Morel et al., 2016; Ferguson and Lovell, 2017). Building on the strong public interest for permaculture, some permaculture farms develop cultural or training activities to diversify their incomes in a logic of pluriactivity. This strategy raises strong criticism from permaculture opponents who argue that permaculture profitability only comes from teaching permaculture and not from applying concretely permaculture to build productive systems. The cost of permaculture training or cultural activities (workshops, demonstration site visits) is another topic of controversy. Critics from within and without the permaculture movement argue that the ways in which these costs limit access to programming contradicts permaculture's principles of equity and sharing. In response, others claim that a fair cost of training has to pay teachers for their time, labor, the depth of their experience, and the value of what they offer. Some permaculture teachers do offer free or limited-cost courses for people who cannot otherwise afford training.

Nevertheless, many permaculture farms only focus on production and are not involved in teaching. The levels of production, inputs, labor, and incomes of farms inspired by permaculture are highly variable and similar in their range to other diversified, organic, low-input., and agroecological farms

(Ferguson and Lovell, 2017; Morel, 2016). In developing countries, farmers using permaculture can experience agricultural, environmental, economic, and nutritional benefits in comparison to farmers solely using conventional agriculture, as demonstrated in Malawi by Conrad (2014). However, benefits of permaculture at the farm level are limited by the broader dominant agro-food system, constraints on access to resources and markets, and wider structural, political, and technical context. Such exploratory works mitigate both idealistic views of permaculture activists presenting permaculture as a way to solve all problems and strong critics presenting permaculture as an unrealizable utopia.

For permaculturists, a high level of biodiversity and functional redundancy are supposed to guarantee that agricultural systems will be resilient. The idea that “diversity begets stability” is deeply anchored in the ecological literature since the 1950s, especially in H.T Odum’s work which has inspired permaculture. The “stability-diversity controversy” running in the ecological academic field since the 1970s has however underlined that the link between diversity of species/functions and stability of ecosystems is complex, and that other factors and properties of ecosystems have to be considered. As many gaps in academic literature remain, further studies are required to examine the efficiency, resilience, ecological dynamics, and impacts of permaculture farms in different contexts, and in the light of contemporary ecological concepts and methods, and to assess the extent to which permaculture could contribute to a large-scale transformation of food systems. Accompanying the growing public awareness of permaculture, recent years have seen a shift in the isolation of the permaculture movement from the scientific community. This bridge is being built from both sides. There is an emerging push for community-based research and partnership with institutionally-based researchers coming from the permaculture movement. For example, the Permaculture International Research Network (PIRN) was formed in 2015, sponsored by the UK Permaculture Association, and reports having over 400 members in over 40 countries. The appearance of permaculture in publications in peer-reviewed journals has increased sharply in recent year. More and more universities are developing research projects about permaculture which may announce promising perspectives for the future.

5 Further reading

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