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MSc-level course

Ecosystem services: a comprehensive introduction to theory and applications (FOR109)

This document contains a collection of some of the essays written by the students participating in the course. The course run (for the second year) in September and October 2017 at the University of Helsinki, Viikki campus. The aim was to provide a comprehensive understanding of the current ecosystem services research, which has rapidly become a key concept in sustainability research and policy making. About 30 students enrolled to the course, including MSc and PhD students from various disciplines, including natural sciences and economics. The course will be organized again during the academic year 2018-2019.

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Ecosystem services and poverty alleviation: maximizing the benefits for impoverished people

1. Introduction

The Millennium Ecosystem Assessment drew much attention to the role that natural capital plays in the creation of human wellbeing on our planet. Since then, frameworks considering ecosystem services (ES) are increasingly gaining popularity among researchers and policy makers (Gómez-Baggethun et al., 2010).

Some research effort has also been dedicated to the question whether ES could specifically cater to the needs of the global poor, increase their wellbeing and thus lift them out of poverty (Sandhu & Sandhu, 2014; Turpie et al., 2008). Accordingly, the global ES initiative TEEB (The Economics of Ecosystems and Biodiversity) mentions ecosystem management and biodiversity conservation as important policy tools to eliminate and reduce poverty (TEEB, 2010). Based on the assumption that the poor are reliant on various services provided by ecosystems, policies that improve local resource bases could lead to poverty alleviation effects.

On the other hand, an increased dependency on ES is associated with declines in overall wellbeing (Shackleton & Shackleton, 2012). Even though the causality of this phenomena remains unclear, it is questionable whether policies that enforce this relationship can effectively contribute to poverty alleviation (Suich et al., 2015).

Evidently, there is no generally accepted theory that explains the impacts of ES changes on the global poor. Thus, this essay aims to understand possible mechanisms and circumstances that lead to an increased well-being of the poor through the conservation of ES. By examining recent publications, I will explore the links that have been made between ES provision and poverty alleviation and conclude my impression in a final statement.

2. ES and poverty alleviation

2.1 Terms and definitions

ES can be broadly understood as benefits that people obtain from ecosystems and may be divided in the four categories of provisioning, regulating, supporting and cultural services (MEA, 2005). Since the definition only includes those natural processes which are useful to humans in terms of their ability to foster our wellbeing, it reveals the highly anthropocentric and utilitarian perspective of the overall approach (Jax et al., 2013). Accordingly, the underlying rationale behind ES research is to optimize the overall output of wellbeing.

The abstract idea of wellbeing can be broken down to the components of security, basic material for good life, health and good social relations (Fisher et al., 2014). Altogether, those constituents are necessary conditions to obtain freedom of choice and action.

In accordance with the terminology of ES science, the state of poverty can be understood as a general lack of wellbeing (Daw et al., 2011). This definition marks poverty as a multidimensional phenomenon which comprises more aspects than the mere lack of financial resources. Poverty alleviation may include the reduction or prevention of poverty, which translates into the increase or perpetuation of wellbeing in areas of high poverty prevalence.

2.2 Established linkages and shortcomings

Studies exploring the links between ES and poverty alleviation have been conducted all across the developing world, most of them in sub-Saharan Africa. Findings suggest that poor households rely on provisioning services such as food, housing or energy in order to meet their demand for material wellbeing (Egoh et al., 2012; Sandhu & Sandhu, 2012; Suich et al., 2015). Furthermore, provisioning services oftentimes form the basis for income generation in poverty stricken areas and many livelihoods depend on them. A meta-analysis revealed that forest environmental incomes account for an average of 22% of the total household income in forested areas of developing countries (Vedeld et al., 2007). However, the contribution of forest environmental income to the overall income decreased with increasing household wealth. Thus, activities such as collecting and selling of fuelwood, wild foods or fodder provide a reliable income source for the very poor when livelihood alternatives are absent. Ecosystem provisioning services thus function as a safety net to the global poor by providing both a source of material and income opportunities.

Paying tribute to this important function, an overwhelming majority of studies exclusively focuses on a single provisioning service and examines its importance for the poor in monetary terms (Suich et al., 2015). Nevertheless it must not be forgotten that both ES and poverty are multidimensional concepts which can hardly be assessed by looking at a single component such as provisioning or income only.

Many authors point out the importance of a differentiated view on those components in order to better understand the mechanism behind wellbeing creation (Daw et al., 2011; Fisher et al., 2014; Suich et al.; 2015). Unfortunately, this concept is rarely put in practice and the role of regulating or cultural services and their contribution to health or social relations is widely unknown (Chan et al., 2012; Suich et al., 2015).

However, there are some case studies which apply a more holistic research approach. An example from the Himalayas illustrates how certain ES are connected to different measures of poverty. While provisioning services were found to improve food and nutrition security by the same mechanism described above, supporting services were associated with the building of agricultural assets (Sandhu & Sandhu, 2012). Another aspect of poverty can be the low accessibility of sanitation and hygiene, but regulating services such as decomposition of organic waste and water quality contributed to the improvement of the situation. Altogether the study provides important insights into the linkages between ES and wellbeing but does not explicitly make a connection to poverty alleviation.

Another interesting approach is the reduction of poverty through the payment for ecosystem services (PES). In South Africa, the government-agency Working for Water (WfW) can be contracted in order improve the water supply in a certain area. By clearing riparian zones of invasive plants species and restoring natural biodiversity, WfW aims to increase hydrological ecosystem functions which ultimately result in enhanced ES in terms of water provision and quality (Turpie et a., 2008). Interestingly, WfW was originally founded as a poverty-reduction initiative while offering the clearing jobs exclusively to formerly unemployed individuals. The program was found to be extremely successful in fulfilling both the purpose of ecosystem conservation and job creation in poverty stricken rural areas. Thus, PES bare the potential to contribute to poverty alleviation by providing a source of income and offering an alternative livelihood strategy to the global poor.

2.3 Distribution of wellbeing

One of the challenges that policy makers all over the world are facing is the accurate targeting of their efforts (Fischer, 2012). With regard to ES and poverty alleviation, a critical point is to guarantee that the poor are actually among the list of beneficiaries. Therefore, one has to consider the distributional effects for each ES and the wellbeing it delivers. Being able to direct the stream of ES benefits directly to the global poor, who are characterized by a lack of overall well-being, would then be a powerful tool in poverty alleviation strategies.

The degree to which the people within a group benefit from increased wellbeing supplied by ecosystems may differ along socio-economic gradients (Suwarno et al, 2016; Daw et al., 2011). Characteristics such as gender, age, social status or income may determine whether an individual finds himself among the wellbeing recipients of a certain ES or not.

In Tanzania, for example, increased market prizes for fishery products led to a higher appreciation of this provisioning service in coastal communities. Suddenly there was a competition for this specific ES and men, attracted by the promising financial returns, took over the fishing grounds which were traditionally occupied by women of low income groups (Porter et al., 2008). Thus, there was a direct trade-off between the well-being of the two gender groups and the effects on overall poverty within the community remain unknown.

The conceptual Ecosystem and Poverty Alleviation (ESPA) framework takes into account the distributional effects of ES and stresses the importance of social differentiation (Fisher et al., 2014). According to this framework, factors such as entitlement, capital, preferences and other means consequently decide which social actors are able to gain access to the benefits of ES. Unlike the TEEB framework, ESPA concept does not aim at valuating the ES in economic terms but helps to predict the changes in well-being provision among groups of different socio-economic characteristics. Such an approach might be helpful within the context of poverty alleviation since it allows policy makers to direct the benefits of ES to a specific target group.

Daw et al (2011) even go one step further and argue that not only the distribution, but also the relative importance of benefits should be taken into account. By pointing out that the marginal utility of wellbeing decreases as wellbeing increases, the authors propose the use of equity weights to evaluate welfare impacts of ecosystem changes. In this way, the benefits which poor beneficiaries receive from ES would gain more weight and would be considered accordingly in ecosystem management decisions. Such an approach would help to emphasize the interest of the global poor which are oftentimes underrepresented in decision-making processes (Fisher et al., 2014).

2.4 Remarks and concerns

A final remark should be made in order not to overestimate the role of ES when it comes to poverty alleviation. It is important to note that ecosystems are not the only source of wellbeing. Technology, infrastructure, healthcare and education are important contributors

to human wellbeing and only indirectly related to ES (Fisher et al., 2014). People refer to those factors when they talk about human development and based on a countries performance in those categories it is marked as part of the developed or developing world. Thus, policies that aim at improving those factors might be more effective in reducing poverty than policies that focus on ES provision. More research is needed in order to identify the most appropriate source of wellbeing for the global poor.

Some concerns have been raised with regard to the compatibility of biodiversity conservation and development goals. Keeping an ecosystem in a natural state oftentimes comes with high economic opportunity costs (Adams et al., 2004). In areas where people are suffering from states of poverty, it is unlikely that they would withdraw themselves from any profitable income source for the sake of ecosystem health. Due to this argumentation, the rural poor have been denounced the biggest threat to the environment for a long time (Fisher et al., 2014). Even though this view has been challenged by the notion that the high consumption lifestyle of the developed world exerts much bigger pressure on ecosystems worldwide, the underlying concern might be justified. Historically, economic growth is tightly connected to environmental degradation and development was achieved by the exploitation of natural capital. Thus, a valid question might be weather keeping functioning ecosystems and eradicating poverty are two compatible goals. As Adams et al. (2004) point out, it is advisable to untangle those objectives and have policies clearly dedicated to one of them. Any attempt to achieve both goals at the same time might lead to contradictions and impediments. Hence, applying the ES approach as a tool for

poverty alleviation could potentially lead to unsatisfying outcomes as well. However, the WfW example discussed earlier provides evidence that poverty alleviation and ecosystem conservation does not per se lead to an internal conflict and gives hope for further successful implementation.

3. Conclusion

There seems to be an agreement in literature that the global poor are more vulnerable to changes in ES provision since their livelihoods are directly based on natural capital. Thus, ES definitely play an important role when it comes to the wellbeing of the global poor. However, much less effort has been payed to the question of how and in which context ES provision can actively contribute to poverty alleviation.

Most studies dealing with that topic focused on the role of provisioning services and examined their effect on poverty by looking at income related measures. However, much less is known about the links between cultural, regulation and supporting services and poverty prevention. Distributional effects of ES and social differentiation complicate the matter as they may redirect the stream of benefits and wellbeing away from the already marginalized poor. Due to a lack of comparative studies, it also remains unclear how useful ES approaches can be in comparison with other poverty interventions that focus on human development.

Summarizing, it can be said that the linkages between ES and poverty alleviation are definitely existent but very complex and widely unknown. There is a need to deepen our knowledge about the potential of ES to contribute to poverty alleviation. Novel approaches such as the ESPA framework or equity weights may supply a useful framework in order to do so.

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How People Deal with the Risk of Declining Ecosystem Services?

Environmental Risk Management DO WE CARE?

What comes to your mind when you heard the word ecosystem service? Is it familiar? Have you read or heard something about this? Now let's try this, sunlight, food, fresh water. Ring a bell?

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For years, scholars and researchers have been trying to define the word 'Ecosystem Services'. "Ecosystem Services are the aspects of ecosystems utilized (actively or passively) to produce human well-being. (Fisher, et al. 2009). The TEEB Foundations in 2010 defined it as the direct and indirect contributions of ecosystem to human well-being. Boyd and Banzhaf (2007) once wrote that Ecosystem Services are components of nature, directly enjoyed, consumed or used to yield human well-being. With such influxes of wording, one thing in common amongst all three definitions are the emphasis on human, how ecosystem services serve its function for human. So, isn't it strange if us, as human being are still not familiar with the term "Ecosystem services"?

i. Ecosystem Services

According to Millenium Ecosystem Assessment (MA, 2005) the services that ecosystem provides us fall into four categories which are Supporting such as nutrient cycles and crop pollination; Provisioning such as water and food production; Regulating such as controlling climate and disease; last but not least; cultural such as providing recreational and spiritual benefits. These four big functions contributes a big part (directly/undirectly) to various aspects of human well-being, such as Human's security, basic material of good life, health, good social relations, and even freedom of choice and action.

Due to the fact that humans are said to be destroying the environment at a rate unprecedented in over 10.000 years, In the later development, scholars like Naeem (2013) are complaining that the biosphere is not designed to serve a single species which is human and will collapse if forced to do so. He claimed that human wellbeing is more likely to be secured if we work in the service of nature than attempt to force nature to work in the service of humanity, and yet troubling trends in habitat destruction, freshwater decline, biodiversity loss, and other forms of eroding natural capital continue to accelerate (Kumar & Martinez-Alier, 2011). The MA (2005) also reported that 60% of the ecosystem services that have been examining during their big assessment are being degraded or used unsustainably.

If we see how ecosystem services' concepts are catered for the human needs, it is actually very obvious that human should have been very concerned about this issue. However, let's look at the current reality, are human aware of it declining? Ecosystem services have become a mainstream concept for the expression of values assigned by people to various functions of ecosystems (Bennet & Elena, 2015) one of them is regulating climate. To make it more apprehendable, later in this essay, the declining of ecosystem services will be represented by current happening phenomena, which is climate change. Let us find out why the most threatening phenomena to human kind is not likely to be seriously handled and well-anticipated.

ii. How human perceived the risk of declining ecosystem services (represented by 'Climate Change')

Human, have been talking about apocalypses for millennia, various of ways, different time period, but terrorism and climate change always rank among the most serious. (Sunstein, 2007, p. 25). According to NASA, "Climate change is a change in the usual weather found in a place. This could be a change in how much rain a place usually gets in a year, or it could be a change in a place's usual temperature for a month or season. It also changes Earth's climate than its usual temperature, or where rain and snow usually fall. While weather change in just few hours, climate takes hundreds or even million of years to change". The causes of the change of the climate mostly result from the way people live in the modern days, burning coal, oil, and gas that cause to put gases to the air and cause the air to heat up. Till date, climate change that caused a warmer temperature was indirectly responsible for the deaths of millions because of starvation and disease.

Climate change effects, though, are not only distant and far but also intangible. As mentioned by Greeven (2016), people question whether it is really happening or not as it has no external enemy. A psychology research shows that mostly society do not feel personally threatened by the issue as it is vague, abstract and hard to picture. Even people in many areas of the world may not even think it will be a problem in the near future. Maybe because we all responsible for it to happen, by the way we live every day, even though nobody intentionally wanting it to happen. According to NASA, last year (2016) was the warmest year that has ever been recorded. Additionally, there is a big amount of natural evidence in the form of glaciers shrinking and sea ice melting to record lows, sea levels rising reaching 20cm, disappearing island, and late springs. As NASA said "There is no question that increased levels of greenhouse gases must cause the Earth to warm in respond."

"There are particular characteristics of risk information which can cause misunderstanding when communicated, and people do not perceive this information as an important "news" which they should react to" (Yamashita, 2009, p. 327). Climate change was not the greatest threat of the world probably because of these three factors. First, the information is "invisible" and "hidden from senses". As we know, senses are physiological capacities of organism that provide data for perception. In other words, we perceive data using the input from

our primary senses: sight, hearing, smell, touch, and taste. "Climate change was understood as a global but distant issue with severe consequences" (Willbeck, 2014, p.204). This distant issue that human is feeling, affect the way they perceive the idea that climate change is nowhere near them. The second one is, "invisible" risk information, which is based on how one perceives risks. Unlike terrorism where attacks are visible, very vast, occurring in a particular area and attracting the attention of the media and people all around the world, climate change happen over a long period of time, it is happening slowly that people cannot even notice. When the time is not known, or 'hidden' it will be difficult for people to understand. The third one is the 'scale-hidden' element. When the scale of information is too small or if we are talking about climate change, too large, it will be harder to perceive risk information. Thus, it supports the reason why the world does not fear climate change as much as they do to let's say, terrorism.

iii. Writers comment on how to raise awareness

Declining of ecosystem services deserves great awareness as it is capable of bringing a big and dangerous impact to the world we live in. But the real question is how to make people actually care about it? In 1968, Garret Hardin proposed a theory which is still famous up to now called Tragedy of the Common. 'Common' here is natural resources shared by many individuals. By 'shared' means no one have a claim to any part of the resource, but everyone has a right to use it. The tragedy here is that in the name of greed everyone tends to the commons to their own advantages, typically without limit. And under thus state of affairs, the commons is eventually depleted and ruined. This theory explains much about human-nature relations in which everyone tries to take benefits from the nature. It is totally fine when everyone puts in mind about the carrying capacity of nature and it becomes dangerous when greed comes around. "If I do not make use of this land as much as I can, others will do it anyway, so I do not see any reason not to do it" this kind of mindset is very dangerous, and leads people to keep exploiting our nature.

We have all heard and read somewhere about it, how to stop climate change, reduce the usage of cars, use less electricity, recycle, but turns out I personally think that making society individually responsible for worsening ecosystem services such as global warming will actually give a vice versa effect and discourage people to engage in an actual action. We are facing our extinction soon but it is still very difficult for anybody to actually do something about it. One of

the ways to get people actually put attention to it and care is to unburden them from individual responsibility in attempting to stop climate change, as explained from Garret Hardin's theory, nobody really wants to feel like it is their fault. A team of social researcher at the University of California, that calls for donations, regarding to global warming problem, proves that it is more effective when 'framed through a collective lens'. People will care more when climate change is shown as a shared responsibility rather than one person's responsibility. It is time to socialize the phenomenon of declining various ecosystem services as a social responsibility through emphasizing the way how to solve it in public setting. So people will not feel that they are struggling alone. The shifting concept from government and governance will come very handy in this planning. It is not only the government which is responsible, but we are all are. Through public setting, it can be institutions like government, offices, schools, they have to facilitate and push their members collectively to contribute to the action of slowly managing and stopping the impacts of climate change, global warming, habitat loss, and various other earth destruction. For instance, for school it is indeed through the lesson they provide for students. "In order to serve society in addressing environmental issues, it is important to provide learning opportunities for students, as future citizens, to develop their understandings and values of environmental related issues" (Treagust, Amarant & Chandrasegaran, 2016, p.5592). I believe that school has a big part in a child's development which is very good to raise awareness towards various environmental problems that are happening around us.

For most individuals, these issues mentioned above still feel like something that happened ages ago, like the ice melting in Alaska, deforestation in Indonesia, haze in china, confusing chart of carbon emission, it does not feel personal, urgent, nor local. Therefore, instead of talking about what could be worsening quality of ecosystem services done to another part of the world, I believe that there will be more success if the message is correlated to each local area, making it seems near to each people in every part of the world. By letting each know what is happening near them, and when government or any other parties would like to deliver the message, it is always better to just tell the people about the worst case scenarios that hopefully will significantly increase the sense of urgency to minimize the impacts of environmental change. For example in Indonesia, Tabaco advertisement is very unique. In the packaging, the company decided to out the picture of a heavy smoker's lungs which looks awful.

This is the kind of advertisement or social campaign, which frankly exposes the worst case scenarios of something, would make a huge difference to increase sense of urgency within people to care more about what is happening. The selection of images for an advertisement is very crucial point to consider as well. I believe that for example, posters with real photo picturing the real condition of our surrounding environment would trigger stronger emotions and directly affect the targeted viewers.

Lastly, social networks nowadays are powerful than ever, and peer pressure as well. In one research conducted by Clean Energy Resource team, a researcher tested to put a sign in a hotel room that stated 75% of guests in the room reused their towels. Then the number of people who reuse their towels rose dramatically. On the other hand, when a similar sign was put off to ask people to reuse towels to save water, it had small effect. That is a problem with conveying message about ecosystem services. It mostly speaks about how only few willing to recycle, bike, use less electricity or save water. And it turns out this type of message could make things worse. And vice versa, we should instead talk about those who get it right. Social movements would also make a big impact, like how gay marriage already does.

Therefore, when there is a strong and active social support and a strong push from government, schools and businesses, building a society which takes care and highly values ecosystem services is not impossible.

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Jani Kärkkäinen

Ecosystem services within Agroecology

Introduction

In this short essay I am pondering utilisation of agroecology and ecosystem services framework together. It seems that there are considerable amount of convergent issues and concepts. It seems that the concept of ecosystem services has already found its way to some common textbooks of agroecology, but utilisation of the whole framework might still be precursory. In this essay it is suggested that more profound blending of ecosystem service research and agroecology might be very beneficial and synergistic. As a case study, my own master thesis (in writing) about oil palm agriculture seen within ecosystem service framework is briefly touched.

Agroecology

Agroecology is a result of the marriage of agronomy and ecology. According to Gliessman (2015), agroecology can be defined as "the ecological analysis of agriculture". Martin and Sauerborn (2013) define agroecology as "the science of the relationships of organisms in an environment purposely transformed by man for crop or livestock production". Gliessman (2015) state, that besides scientific aspect agroecology has also practical and social-change aspects. Wojtkowski (2016) argues that

agroecology is "a foreign creature": for ecologists it might be too economy oriented, and for agronomists too theory driven. Also, Martin and Sauerborn (2013) state, that beyond the ecological meaning, concept of agroecology "is not clearly defined and can have quite different meanings" from a scientific discipline to an agricultural practice and to social or political movement. As a novel discipline, agroecology is relatively young, dating back to 1990s, nonetheless concept started to take form some 70 years earlier. Agroecology emerged in 1970s as an answer to the adverse effects of industrialised agriculture to the environment and human welfare – first as movement and set of alternative practices. Then on 1980s, agroecology developed as "the scientific bases of alternative agriculture" and 1990s applied concept of sustainability in management of general agroecosystems. It developed from "field or agroecosystem scales toward a larger focus on the whole food system" (Martin and Sauerborn 2013). Today goal of agroecology is to study complete food systems from singular plant level, trough farms, trough anthropomorphic landscapes up to food chains in society and economy and enhance their sustainability. It is very holistic science taking account environmental, social and economic aspects of food production as a whole. In the agroecological analysis human beings are part of ecosystems, not unnatural outsiders. Roughly speaking, as a discipline agroecology deals with the different ecological levels such as field, agroecosystem and food system; as movement it encompasses environmentalism and rural development leading to sustainable agriculture; as a practice it includes specific alternative agricultural techniques (Martin and Sauerborn 2013). Agroecology is a discipline to enhance sustainability of food production.

Central concept to agroecology is agroecosystem. The agroecological hierarchy can be arranged according to three levels which are agroecosystem, landscape and food system (Gliessman 2015). An actual agroecosystem can be defined as a site or integrated region of human manipulated ecosystem for the purpose of agricultural production. The concept of agroecosystem is usually delimited due to need to measure inputs and outputs of a certain agroecosystem like a farm or group of farms. If agroecosystem is defined very broadly, system analysis might be difficult to carry out. A broader concept and systematically next level from agroecosystem is the landscape. On landscape level agroecology studies interactions between agroecosystems and natural, semi-natural or other rural or urban land use options. Usually agricultural landscape is a mixture of various kinds of ecological niches and patches accounting complicated ecological mosaic, conceptually boundaries of agroecosystems and natural ecosystems can be arbitrary Agricultural landscapes are multifunctional where "natural ecosystem services blend with agroecosystem processes" (Gliessman 2015). As a result, interactions betwixt natural and agricultural ecosystems can be complex enough not to be easily distinguished from each other. In local or regional context agroecology studies food systems which comprise "networks of food production, distribution and consumption" (Gliessman 2015). Food systems includes all stakeholders participating in it, logistics, manufacturing, governing, "and the larger economic, sociocultural, and political structures within which food production and distribution occurs" (Gliessman 2015). These food systems might be local or regional, but together these forms the global agro-food system.

Above mentioned classification of agroecosystem levels cannot be totally fixed since there are many different ways to define agroecosystems (Khrishna 2014). Depending on features to highlight - such as "the geographic area, weather pattern, natural resources, cropping pattern, and products" (Khrishna 2014) - some agroecosystems can be very large indeed to cover different regions and even continents such as Wet Land Rice agroecosystems of South-East Asia, Temperate Wheat Cropping Zones of European Central plains or Citrus plantations of Florida.

System is sustainable if it is able to maintain its function over time. In agroecological framework sustainability is tried to reach taking account environmental and socio-economical features. Gliessman (2015) lists features for sustainable food production which can be summed up as: minimal negative effect to nature, climate and soil; preserving and rebuilding soil fertility; minimising greenhouse gas emissions; conserving biological diversity; socio-economic and political equality; and food security.

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Ecosystem services framework

"Ecosystem services are the benefits people obtain from ecosystems" (MEA 2003). Ecosystem services are divided to four different categories in the Millennium Ecosystem Assessment (MEA) framework (MEA 2003). These functional categories are at some degree flexible and overlapping. Supporting services are the base for provisioning, regulating and cultural services.

According to MEA (2003): "Ecosystems are essential for human well-being through their provisioning, regulating, cultural, and supporting services". Change in the quality and amount of ecosystem services reflects directly and indirectly in well-being altering level of livelihoods. Direct effects occur rather immediately trough "locally identifiable biological or ecological pathways". Indirect effects may take decades to occur and they "happen through complex webs of causation, including social, economic or political interactions". Whether an effect is direct or indirect it can have positive or negative impacts. However, MEA does not understand ecosystem services only as an instrumental means to enhance well-being, but redress them as "constitutive elements of well-being". According to MEA (2003) the challenge for society is to sustain functional ecosystems and at the same time utilise their services to enhance human well-being and livelihoods. This can happen if people have access to such a way of life where "equity, sustainability, livelihood, capability, and ecosystem stewardship" are possible and respected. Certain sphere of freedom must prevail: according to MEA (2003) these are participative freedom, economic facilities, social opportunities, transparency guarantees, protective security and ecological security. These creates a social environment where individuals can define their rights and "to create institutions to protect and oversee a fair and equitable distribution of these rights for all members of society". To produce well-being, besides adequate ecosystem services, societies need functioning institutions and stable structures for decision making. Furthermore, according to MEA (2003) there must be also powerful incentives to overcome short-sighted need to rapid gains at the expense of sustainability. Value systems play an important part.

The concept of ecosystem services is rather young not unlike discipline of agroecology. At the same time than agroecology developed as academic discipline during 1990s also happened mainstreaming of ecosystem services-concept (Braat & de Groot 2012). Probably similar ecological concerns have been thriving their development. Whereas agroecology concentrates agroecosystems and food production, ecosystem services framework advocates conservation of natural ecosystems with strong connotations to anthropocentric well-being. The ecosystem services concept has evolved to a major framework including large body of concepts. It can be used for example in decision making, as a conceptual framework for research and valuation or as assessment of ecosystem services. Framework tries to understand interrelations between ecosystems and well-being of people and at the same time conserve biodiversity. Ecosystem services framework includes ecosystem side and anthropogenic side. It combines these two to a same framework and includes different theoretical models for their interaction from ecological and economic sciences. Millennium ecosystem assessment brought together ecosystem services and constituents of human well-being and The Economics of Ecosystems and Biodiversity (TEEB 2010) developed concepts further applying so called cascade model. With ecosystem services framework it is possible to value ecosystem services monetary and non-monetary ways. These again are utilisable in decision making. (Braat & de Groot 2012; Bennett et al. 2015)

Ecosystem services framework together with agroecology

Some researchers might have had some reservations of why to use ecosystem service framework with semi natural or anthropomorphic ecosystems since it was originally developed as a tool how to identify ecosystem benefits that natural ecosystems provide for human beings. Does the assessment work also

outside of natural ecosystems? Also, hence the ecosystem framework assessment is based ideologically to conserve biodiversity, can it be combined to the biodiversity destructive forms of land use modes?

As about 50 % of terrestrial global area is utilised for producing food, this ecological man modified niche is very important from biodiversity's point of view. Gliessman (2015) discusses about multifunctionality of agricultural landscape: "When a landscape is made up of patches of relatively natural systems and agroecosystems that are managed both to produce food and to enhance and protect biodiversity, it can be considered a multifunctional landscape". Gliessman (2015) recognises "the critical value of biodiversity and ecosystem services". Here ecosystem services framework converges with agroecology.

I think that in this kind of multifunctional landscape the ecosystem service assessment can be used and can offer information about the state of ecosystem services. It can be used as a tool for conservation, but also for rehabilitation of degraded ecological niches. I believe that agricultural landscape can be significant source of ecosystem services. Since agroecological land use is very widespread and even dominant land use scheme globally it is quite reasonable to apply ecosystem services framework to agricultural landscapes. Ecosystem services framework can further help to identify important ecosystem services and help to develop food production to a more sustainable direction.

Some ecosystem services in the oil palm based agroecological landscape

I am preparing my master thesis about smallholders' well-being in an oil palm (*Elaeis guineensis Jacq.*) dominated landscape (Kärkkäinen 2018). I am trying to assess ecosystem services in the oil palm agroecosystem on the landscape level and then to observe some of their well-being effects. I am combining agroecological system analysis with theoretical framework of millennium ecosystem assessment (MEA 2003). Palm oil is the most produced vegetable oil in the world (FAOSTAT 2012) and hence important source of energy in human diet. Study is based on about 60 households' interviews of mainly Petalangan ethnic in two villages in the island of Sumatra, Indonesia. In my study area oil palm cultivation was introduced to locals by a certain palm oil company and then made available for villagers through cooperative smallholder scheme. Oil palm industry has quite bad general image whether discussion deals with ecological or socio-economic aspects. My research imply that situation might not be that black and white as it is often discussed publicly. In this short essay I touch only some issues.

The Petalangan used to be culturally as well as for subsistence very dependent on their natural surroundings (Effendy 1997). According Effendy (1997) this connection was degrading already in the 1990's and seemed to be continuing to do so according to my study (Kärkkäinen 2018). Their main sources for livelihood are nowadays oil palm agriculture (as workers on plantations or as smallholders), rubber patches and fishing. Due to logging and different plantation practices forest on the area are almost disappeared (though some thickets and bushy areas remain) and hence their role as ecosystem services providers has radically diminished. But palm oil dominated landscape (or oil palm based agroecosystem) still manages to provide some ecosystem services and functions.

In my study area, from the oil palm dominated agricultural landscape, the major ecosystem services seem to be palm oil and rubber from *Hevea brasiliensis*, which in turn were exchanged to money. And it is something what local smallholder seemed to value above anything else. Some practised hunting, but fishing was common trait almost in every household. Firewood was main method for heating food, and collection from thickets or rubber plots was done weekly. Vegetable growing was almost inexistent, but instead large variety of fruit trees and semi wild plants around houses was used as source of food, also mushrooms were collected from rubber and oil palm plots. Some had chickens as livestock. Surroundings were still source for natural medicines that local medicine men or women, called 'dukun', were prescribing, and were commonly utilised among villagers. The Dukun made from forest products

also some magical remedies and amulets that were used against bad spirits. Also, some holy trees, called Sialang trees (source of honey) remained, but not as before, since they were cut down by the plantation companies. These are identified mainly as provisioning services, but the last ones can be seen also as cultural or religious services. In my thesis I am dealing also with these and other service types more specifically (Kärkkäinen 2018).

It was quite obvious that local environment was largely changed after the oil palm was introduced to the scene (Kärkkäinen 2018). However, villagers under my scrutiny were quite satisfied to the situation and seemed not to miss forests lost. For my surprise, some were even happy that there were no more big forests left, because they were considered dangerous due to wild animals and malevolent spirits. Money from oil palm was considered very important: it gave them possibility to better education (e.g. children), livelihood and allowed more free time. In short, income from palm oil raised the level of well-being well over subsistence level. Also enhanced roads made by palm oil plantations gave better access to and from villages.

Petalangan case is an example of practices that one palm oil company had taken incorporating locals to its corporate policies by cooperatives. In the Petalangan area there were also companies that did not take account indigenous habitants at all, and probably in those areas sentiments might not be that favourable. It is also clear that ecologically oil palm based landscape is strikingly different and impoverished when compared to pristine forest of biodiversity hotspots.

Conclusion

Food production is literally vital for survival of human beings. Food can be thought of as a minimal requirement for subsistence. When there is surplus of food there is possibility for everything else that makes human beings human: formation and development of societies and culture with all its different aspects. But the surplus of food has caused vicious circle of population growth and raised demand for food, which has now beginning to threaten not only survival of human beings but the whole biosphere. But of course, the whole scene is much more complicated than mere comparison between population growth and amount of food produced.

Agroecology and ecosystem services framework have similar goals. Where agroecology tries to enhance agriculture as a sustainable practice, the ecosystem services framework tries to enhance sustainability of ecosystem utilisation as a whole. They both concentrate on how anthropocentric actions for ecosystems can be carried out sustainable ways, and conserving nature, but such a way that anthropocentric well-being is still produced. I see that agroecology can benefit from ecosystem services research and vice versa. There seems to be many convergent issues.

Ecosystem services framework has been very useful for me (student of agroecology) as a research tool to understand smallholders' well-being in my research area. It has also revealed some valuation patterns that could be important to take account when dealing with local indigenous farmers if presenting some conservation or rehabilitation schemes. Significance of indigenous people's well-being and livelihood should not be underestimated in conservation. Also palm oil companies are in major role in how to rehabilitate, or in the case of plantation expansion, how to incorporate more agroecologically sound land use methods to their practices. Ecosystem services framework could probably be important tool when raising environmental awareness among palm oil industry as well among indigenous people.

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Assessing and evaluating soil ecosystem services in agricultural soils – critique and frameworks.

Forgetting the intrinsic value of nature is a danger associated with the use of ecosystems services approach to analyse and assess the relationship between human and nature. The further the concept is taken from natural ecosystems the higher is the risk of misusing it. Non-the less applying the concept to anthropological systems offers new ways to understand and manage human influenced systems that cover a substantial part of the Earth's crust. Most food used for human consumption is produced in managed ecosystems and soils are one the components making the production possible. New concepts related to soils such as critical zone services might provide new understanding into the management of natural capital.

Can the ES concept be applied to agricultural soils?

Ecosystem services (ES) are the benefits people obtain from ecosystems (MEA 2005). The ecosystem services concept was created in the context of natural ecosystems (Braat & de Groot 2012). As Power (2010) states, agroecosystems cover some 40 % of Earth's terrestrial surface. An even larger area is covered by other human influenced systems. The need to assess, maintain and enhance ES in managed ecosystems has given rise to new study methodologies for designed or engineered ecosystems and hybrid and novel systems (Palmer et al. 2004, Sandhu et al. 2008, Higgs et al. 2014).

The disservices to natural capital caused by engineered ecosystems have led to discussion about the ability to better safeguard natural capital and utilize ES in designed systems and the ability to substitute some ES with natural or artificial alternatives in the future (Power 2010, ten Brink et al. 2009, Braat & de Groot 2012, Sandhu et al. 2008, Sandhu & Porter 2013). In agroecosystems such substitution (green revolution) has both helped to feed the Earths growing population but also led to trade-offs (Power 2010, Sandhu et al. 2008). The trade-offs caused by managed ecosystems affect both the managed ecosystems and natural ones and some writers (Sandhu et al. 2008, Sandhu & Porter 2013) argue that the effect the managed ecosystems have on the remaining natural ecosystems is among the strongest arguments why understanding and utilizing of ES in engineered ecosystems should be one of the focuses in ecosystem services research. The existing and developing attempts to better govern the use of natural capital gives tools (Hauck et al. 2016) that can also be applied to engineered ecosystems.

Applying ES approach to intensely managed ecosystems leads to some practical issues as well. As the services derived from engineered ecosystems are influenced by human input, trying to evaluate ES or the benefits derived often results to overestimating the contribution of ES into production of goods in such systems (Power 2010; Schröter et al. 2014). Not only distinguishing between natural ES and anthropological inputs is difficult, managed ecosystems rely heavily on services such as provisioning of clean water provided by neighbouring natural ecosystems (Power 2010). Schröter et al. (2014) suggest that ES concept should only be applied to natural processes that contribute to the production of the goods, not the goods themselves. This would revolutionise the ecosystem services research in the context of managed ecosystems. The provisioning services providing food and fibre are generally counted as ES flowing from managed ecosystems like agroecosystems (Constanza et al. 1997, Sandhu et al. 2008, Power 2010).

The problem of double counting was first analysed by Fisher et al. (2009) in economic evaluation context concerning the Millennium Ecosystem Assessment (MEA) (2005). Many soil services are easily double counted. Soil ES such as nutrient cycling, soil formation and erosion regulation are classified as supporting services in the MEA and therefore are seen to contribute to the other three service classes (provisioning, regulating and cultural services). Fisher et al. (2009) suggest the division to intermediate and final services depending on the directness of the link to human welfare. Haines-Young & Potschin (2013) propose that when using the MEA classification only the three final service classes should be evaluated to avoid double counting. This approach would make it difficult to assess individual soil ES as for example nutrient cycling (a supporting service) contributes to several provisioning and regulating services. A tool to evaluate individual ES, including intermediate ES, can be found from the cascade model presented by Haines-Young & Potschin (2009) and modified by de Groot et al. (2010).

From ecosystem services to critical zone services - looking for a unified framework for soil ES

Ecosystem services are strongly related to biotic nature (Braat & de Groot 2012.) To expand the context to better incorporate physical structures like topography, orography and soil parent material and to better consider the spatial and temporal scales that are required for soil formation and long term biogeochemical cycles some writers have proposed to use critical zone services (CZS) instead of ES (NRC 2001, Field et al. 2015, Jónsson & Davíðsdóttir 2016). The critical zone is defined as the zone from vadose layer to the top of the tree canopy (NRC 2001).

The term Soil Ecological Infrastructure describes the soil natural capital, its properties and soil support functions and their dynamic relationship with soil processes (adapted from Jónsson et al. 2017). Dominati et al. (2010) define soil natural capital as the stock of natural resources found in soils yielding a flow of ecosystem goods and services into the future. Soil natural capital is characterized by its

properties. Soil formation and degradation and the soil properties and processes where ecosystem services are derived from are similar in natural and managed soils. Some of the properties and processes however are influenced through management decisions like liming, tilling, drainage and application of fertilisers and agrochemicals. Dominati et al. (2010) propose to divide soil properties into inherent and manageable properties and components. Soil ES however are always the result of both inherent and manageable properties.

A unified classification of soil ES has not been presented. Most papers concerning soil ES follow the MEA (2005) classification, but a number of writers have attempted to create a classification better suited to soils Dominati et al. (2010). Dominati et al (2010) present five soil ES classes based on the different soil roles found in literature. The European Union 7th Framework Programme project Soil Transformation in European Catchments (SoilTrEC) builds on the newly formed concept of CZS and presents a computational model that integrates both biotic and abiotic data like biomass production, climate data and soil properties data to both assess the current ES derived from the soil in question and to predict the future trends in the development of soil ES based on the idea of soil lifecycle (Jónsson & Davíðsdóttir 2016, Jónsson et al. 2017).

The five soil ES classes in Dominati et al. (2010) are services concerning plant growth, water provision and water quality, habitat and health. Notably cultural services were left out of the framework. The SoilTrEC framework includes three service classes: filtering on nutrients and contaminants, climate regulation and biomass production (Jónsson et al. 2017). Even though the SoilTrEC framework heavily relies on the work of Dominati et al. (2010), some soil services, like the services related to habitat are excluded from the framework presented by Jónsson et al. (2017).

Because of the complex nature of soils, proxies are needed when assessing soil ES. The proxies chosen vary between different studies (Jónsson & Davíðsdóttir 2016, Dominati et al.2010). In agroecosystems research the proxies chosen are moving of earth by earthworms for soil formation and nitrogen fixation for nutrient cycling (Sandhu et al. 2008, Sandhu & Porter 2013).

Conclusions

There are both theoretical and practical considerations when applying the ES concept to agricultural soils. They stem both from the definition and the frameworks presented for ecosystem services. Because engineered, novel and hybrid ecosystems cover such a substantial part of the earths surfaces and the trade-offs caused by the management of these systems without understanding the biological principles controlling the processes in these systems are so well documented, new ways to study and manage human influenced systems are needed. The need to build a unified framework for soil ecosystem services is clear. Because of the complex nature of soil processes the harmonisation of proxies used to

quantify ES is also needed. New concepts such as critical zone services aim to give a more holistic view of the services provided by both the biotic and abiotic nature and to provide new understanding to the spatial and temporal scales that affect natural capital and its sustainable use.

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Ecosystem Services: Call for post-Cartesian re-conceptualization

Introduction

At present, our global agroecosystem faces a number of interlocking challenges which concern all species of life on earth. Among the most pressing challenges, we see widespread biodiversity loss, food insecurity, poverty, malnutrition, and neoliberalist policies that perpetuate exploitation, often to the detriment of Earth's most vulnerable social and ecological communities. Without one clear path for how to do so, these complex challenges loudly and clearly demand global food system transformation.

In the face of necessary agricultural adaptation to meet the unknown needs of a changing climate, and to find solutions for a food system which has left 2 billion people either malnourished or overweight/obese, we must recognize that our historically ingrained tendency to view nature as one

system which is exploited by humanity, another system, only works to hinder transformative research within the discipline of agroecology. This Cartesian perspective, which separates humanity from nature (Moore 2017), serves only to perpetuate the violence embedded within the industrial agricultural model. With this in mind, fundamental conflicts between a postCartesian agroecological perspective and our current conceptualization of ecosystem services begin to solidify.

Precise verbiage for the conceptualization of ecosystem services has continued to evolve over the last two decades (Braat and de Groot 2010). In response, we've seen forms of ecosystem service classification and categorization become malleable in order fit the specific goals of different disciplines within environmental science and economics. The classification system proposed by the Millennium Assessment Goals in 2005 establishes 4 distinct categories of ecosystem services, including supporting, regulatory, provisioning and cultural. From this definition emerges the space to discuss non-commodity exchanges in urban agroecology (for example, sense of place and food citizenship) as one facet of cultural ecosystem services.

In the following essay, I argue that the post-Cartesian perspective, which recognizes a cogovernance between all interspecies dependencies, can shape not only the trajectory and politicization of ecosystem services science, but also shape decision-making within research design and implementation at the researcher-level. By embracing social structures as distinct from nature, though equally products of nature (Moore, 2017), we may continue to explore our conceptualization of ecosystem services and design agroecological research in a way which will support all interspecies dependencies in our global food web, and continue moving our research towards food system transformation.

The overlapping of human and non-human nature

Within the iconic conservationist text A Sand County Almanac, Leopold writes, "We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect," (1949). While his above verb choice "to ab/use" does continue to perpetuate a similar sort of 'producer/consumer' relationship between nature and humanity that we see in the industrial agricultural model between food growers and food eaters, Leopold does create space for early-environmentalists to begin situating society into the natural community. The above quote illustrates the power of science to influence the direction in which we move forward with ecosystem service research and action, which holds the scientific community accountable for creating discourse that reflects humanity as one species within a larger network of species.

Moore explains that "the accumulation of capital [within capitalism] is a web of interspecies dependencies, and those interdependencies not only shape capital, but are shaped by it," (2017). When considering ecosystem service-centric examples for how interspecies dependencies are shaped by capital, one might choose to look towards urban migration in the Global South (GS). As climate change alters supporting and regulatory ecosystem services, disproportionately affecting the most vulnerable of farming communities (Gliessman 2015), we continue to observe the resulting swell of migration from rural to urban landscapes in the GS. These associations highlight one negative feedback loop present within our global food system, where increased migration towards cities results in the necessity for more urban space. Ultimately, this loop contributes to repurposing space which could otherwise be cultivated as agricultural land that maintains supportive and regulatory services (with of course, the resulting potential to reduce regional food insecurity and strengthen cultural and provisioning services). In this regard, the overlapping network of human and non-human nature interactions become more visible.

The politicization of ecosystem services science

One recurring theme within our evolving and malleable definition for ecosystem services remains to be the distinction of nature, as one system, which supports human well-being, another system. This distinction works to perpetuate the logic that currently supports the industrial agricultural model, which

actively and unabashedly disregards the biophysical processes which make this globalized production system possible. Decades of strengthening empirical data within the discipline of agroecology (commonly accepted as a science, practice, and social movement), support the notion that without regard to the temporal scale at which biophysical rejuvenation will occur under the above production conditions- our current food system will fail us (Wezel et al. 2014).

While capitalism has worked to inflict violence upon all human and non-human life, with its distinct emphasis upon endless growth and exploitation of social and ecological systems, Moore argues that we must design solutions outside of the 'humans do bad things to nature' trope we have become inured to over time (2017). If so-called forward-looking approaches to ecosystem service research and food system transformation fail to implement research that falls outside of this trope, we, as a scientific community, will continue to isolate humanity as one species apart from the rest. In turn, our new knowledge generation and endeavors to apply monetary valuation

to the benefits that "nature" provides to "humanity" will contribute, at best, to food system (re)formation rather than transformation. While the role of non-monetary valuation of nature's benefits that are enjoyed by humans may operate outside of a capitalist growth framework (Kuman and Kumar 2008), and are indicative of transformation-oriented research, this verbiage continues to engrain in young researchers the acceptability of conceptualizing humankind as a species which operates in isolation from the rest.

As certain capitalist entities increase in both legal and economic power, so does their capacity to influence the funding of research questions that directly impact their power structure. This includes increased influence over which parties are involved in their funding and research development processes. In turn, their influence upon the ways in which new knowledge is reported and interpreted increases in possibility and breadth. Commonly referred to as the politicization of science, we would be remiss to dismiss this phenomenon as not distinctly connected with, what Moore refers to as, Two Systems thinking (2017)- and many would recognize as the fallacy of the nature/culture dichotomy.

The inaccessibility of small-scale food producers to agro-environmental scheme subsidies within the EU's Common Agricultural Policy (CAP) is one example of how the politicization of ecosystem services science influences what is researched and what is left unexplored. Bridging the divide between distinctly agroecological research and distinctly ecosystem services research, it seems as though this so-called Two Systems thinking remains to be one consistent barrier to moving forward with institutional (and social discourse) restructuring processes.

Decision-making within ecosystem service research design and implementation

As argued above, the umbrella trajectory of agroecological ecosystem services research is shaped by the socially-accepted attitudes of the institutions and individual researchers who conduct new knowledge generation within the agricultural sciences. Leading experts in their field, Francis et al., have defined the discipline of agroecology as "the integrative study of the ecology of the entire food system, encompassing ecological, economic and social dimensions. This definition will... stimulate a focus on uniqueness of each place… expand[ing] our thinking beyond production practices," (2003). This definition reminds us that research trajectories within the umbrella study of agricultural sciences have not always questioned and explored the multifaceted complex of interspecies dependencies in the way that agroecology does now. By incorporating this sentiment into the core of the discipline, we are able to more clearly visualize social structures as part of nature, allowing "us to explore socio-ecological connections that make us specifically human- not just exceptional" (Moore, 2017).

Meanwhile, Bennett et al. reminds us that ecosystem service research has not yet established a robust understanding of how "social conflicts and inequities aris[e] from access to specific ecosystem services by different individuals and groups," (2015, pg. 78). Without this understanding, we are unable to build policies which anticipate how access to varying services will most likely affect the well-being of

different stakeholder groups. Put into conversation with one another, these references reiterate the necessity of re-working our current ecosystem services conceptualization (that structurally reinforces Two System thinking) in order to create research

and policy opportunities for value assignment of interspecies dependencies in a what that recognizes humanity as one species within the larger Earth system.

Ethical implications of Two Systems thinking in ecosystem services research

While there seems to be little space within the field of agroecology for Two Systems thinking (Moore 2017), it is critical to take a step back and situate agroecology within the larger environmental science research community. I have come to see a large portion of ecosystem service research as driven by solution-oriented aims. In turn, it becomes apparent the unique role ethical valuation plays in how ecosystem service research is conducted, evaluated, and utilized in agroecological decision-making processes. Because of this unique role, stark contradictions between (inter)national environmental policies and decades of empirical data from leading ecosystem service experts begin to clarify.

The study of applied ethics has given us consequentialist theory, which brings with it a distinct focus on the consequences of a proposed action. Framed in another way, the aim of this type of ethical calculation is to maximize the good of a proposed action and minimize unwanted consequences. Haines-Young and Potschin explain that the development of new environmental policies and management strategies "often involves weighing up the consequences of proposed actions." (2010, pg. 3). They go further, and claim that we must "consider impacts upon ecosystems as well as the social and economic systems to which they are linked- so that the choices society makes are as well informed as possible," when developing new environmental policies (2010, pg. 3). With consequentialist theory in mind, it becomes apparent the vast array of ethical valuations that are critical to decision-making within agroecological-specific research and the resulting power they maintain in the generation of new knowledge.

A wide variety of valuations of ecosystem services has been established, with possibility for both qualitative and quantitative valuations of biophysical, social, and monetary benefits. Included in the aforementioned valuations, is the question of how different impacts upon ecosystem services are evaluation within relation to one another. For example, how do we assign value and priority to questions of species biodiversity vs. biodiversity abundance or short-term vs. long-term food security? Viewed through a post-Cartesian lens, as explained above, we see that role of the researcher (and their lived experiences in place) will affect the outcome of the ethical valuations embedded within their research design, and ultimately what new knowledge is generated.

Conclusion: Call for new language

As described above, a post-Cartesian perspective is deeply conflicting with the established conceptualization of ecosystem services (Moore 2010). The aforementioned examples reinforce both Francis et. al and Moore's call for transformative food system research that include humanity as one facet of nature. In an attempt to heed this call, we are reminded of the possibility of altering the language surrounding ecosystem services discourse in order to reembed human nature as only one interdependent species of the entire Earth system. For ecosystem services to retain value under the framework of this language, we must re-distribute emphasis away from the "benefits people obtain from ecosystems" discourse outlined by the Millennium Assessment of 2005, and move to re-emphasize people as a product of ecosystems.

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