REGEN10 ECONOMIC TRANSITION PATHWAYS FOR LANDSCAPE AGRICULTURAL AREAS

METHODOLOGY

NOVEMBER 2024

Developed by Systemiq.earth on behalf of Regen10.org

Regen10 economic transition pathways for landscape agricultural areas

This study estimates the costs and benefits of altering farming practices and land use within the context of farm economics. The methodology is applied at a landscape level, with six global landscapes selected to demonstrate its application. Each landscape is a geographically contiguous area, primarily focused on food production, chosen for its economic and ecological significance. The principal modelling output is a temporal comparison of farm revenues, costs, and profits before and after implementing context-relevant regenerative agricultural practices. Additionally, environmental and social consequences of the proposed agronomic transitions are qualitatively estimated based on the draft version of the Regen10 landscape-level outcomes framework.

This methodology paper complements the slide deck presentations for each landscape case and includes an Excel model, which serves as a generic blueprint for developing economic analyses of transition pathways for other landscapes

Approach and rationale

The principal objective of this work is to understand how agricultural profitability and the environment would be affected if all farmers within the same landscape collectively adopted context-relevant regenerative approaches, and to identify the drivers of this change. We demonstrate the economic case for incorporating these practices, using landscape examples to illustrate the case across different global geographies and production contexts

This work contributes to forward-looking analyses developed by Systemiq and other research entities, aiming to expand the limited body of literature on the economic implications of transitioning to regenerative practices at a landscape level.

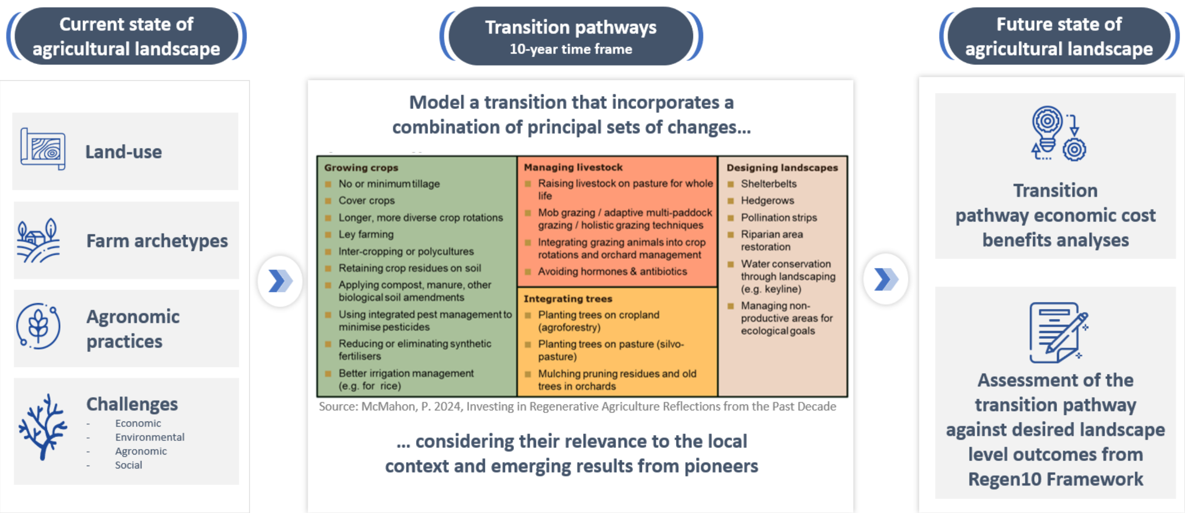
Our work aims to illustrate its potential by applying the same approach and methodology to diverse locations, production systems, and agricultural portfolios with well-understood ecological and economic characteristics. Within each location, a recommended package of changes to land use, production mix, and technologies is developed and its costs and benefits analysed. Up to two archetypes are selected per landscape, each with a distinct package of context-relevant regenerative agriculture practices, developed with reference to local literature and consultation with local experts. The recommended mix of solutions varies across landscapes, in accordance with local context and available evidence.

Context-relevant regenerative agriculture practices encompass changes in land use, production mix, and production technology aimed at improving economic, social, and ecological outcomes. The initial version of the Regen10 outcome-based framework for landscapes lists these outcomes as increased value creation, revenue resilience, access to nutritious food, improved soil health, biodiversity, water quality, and reduced greenhouse gas emissions (Figure 6). Practices for the transition were selected based on their feasibility and intended results within the study's scope. However, broader evidence linking practices and outcomes is still needed, highlighting the importance of developing an outcomes-based framework, which Regen10 is currently undertaking.

There are many pathways to creating a regenerative landscape. The proposed approaches for each case are not prescriptive. Practices were chosen after careful contextual analysis of their relevance and evidence of their intended outcomes. Recognizing that solutions need to produce positive environmental outcomes and be financially attractive for farmers, we aimed to balance regenerative ambition with transition feasibility. We focused on alternatives with a higher probability of achieving farm-level profits equivalent to or greater than before within a 10-year timeframe, while laying the foundation for deeper landscape regeneration in the long term.

The general approach and principal stages followed in the enquiry were as follows:

General approach:



Principal stages:

1. Select, delineate and access six agricultural landscapes.
2. Develop a methodology for estimating the costs and benefits of a transition that can be applied to different landscapes.
3. Define a desired future state for the landscape after 10 years, incorporating context-appropriate regenerative agricultural interventions.
4. Estimate and compare the current and future farming profits (cash flows) of the transitions over a decade.
5. Estimate qualitatively the environmental and social outcomes deriving from the envisioned transition.

The following chapters provide further information on each of the stages.

1. Select, delineate and access six agricultural landscapes:

Landscape and focus agricultural product selection

The combination between countries and agricultural products was made based on geographical representation, impacts of production, data availability, and applicability of results. The choice of landscapes was primarily driven by their national-level importance in the production and export of the specific products.

The criteria for the selection funnel are as follow:

Impact

AGRICULTURAL PRODUCT	COUNTRY
List of world's most cultivated food products (crops & livestock) by volume & area Adjusted for nutritional value	Short-list countries which are major producers of these products

Representation

DIVERSIFICATION	INCLUSION
Assure selected countries are from diverse regions of the globe	Assure IPLC and/or smallholders are main actors in the production of targeted ag product in at least one country

Feasibility

DATA AND EVIDENCE	KNOWLEDGE AND NETWORK
Adjust list for confidence in availability and the team's ability to collect trustable data for the country and agricultural product	Adjust list for team experience and network on similar countries/ag products/ landscapes

Applicability

USEFULNESS	NATIONAL RELEVANCE
Prioritize landscapes where there is a credible and active landscape initiative that could directly inform and benefit from results	Check level of importance of the landscape to the national production and export of selected ag products

The selected landscapes represent a diverse group of the world's agroecological zones, farming types and land-use models. Detailed descriptions of these landscape characteristics can be found in slide deck presentations.

Country	Landscape	Focus Ag Product
Brazil	Querência City	Soy & Beef
India	Punjab State	Rice
United States	North Dakota	Wheat & Maize
United Kingdom	East England	Potato
New Zealand	Waikato Region	Dairy

Following the establishment of the initial five landscapes based on the specified criteria, a sixth landscape was chosen in Africa in partnership with a local civil society organization. This ensured that all continents were represented.

Kenya	Murang'a County	Tea, Maize & Beans

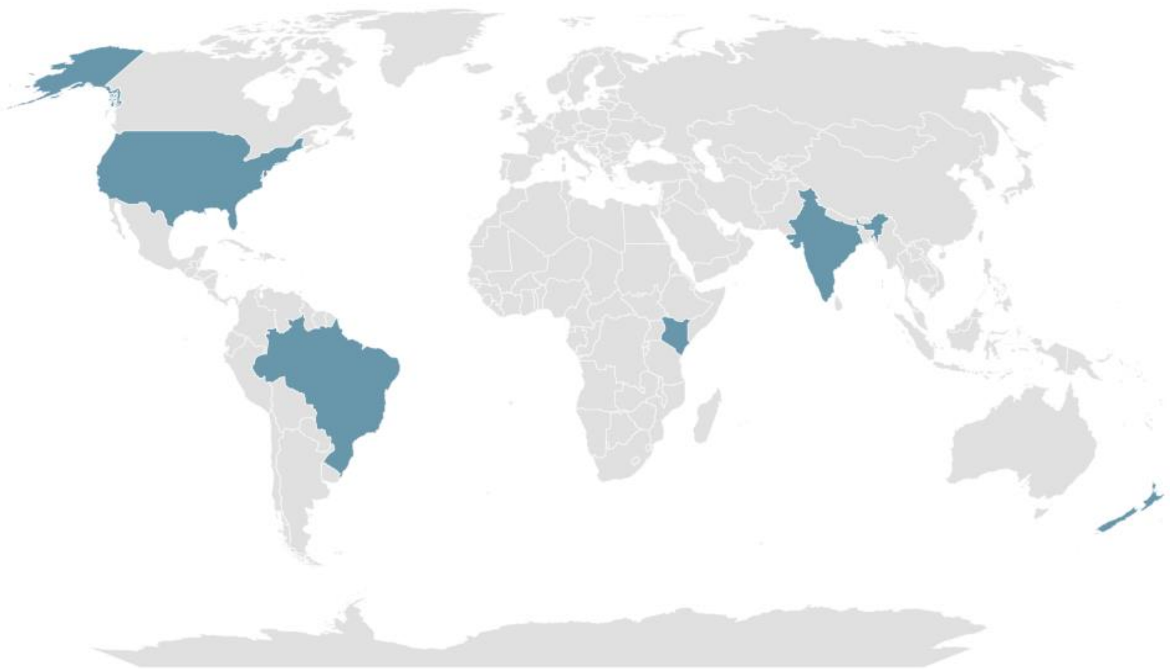


Figure 1- Global map with selected countries.

LANDSCAPE delineation

For our analysis, we adopted a jurisdictional approach within the broader landscape framework. Focusing on jurisdictional boundaries proved more practical due to the availability and organization of data. Administrative units, such as cities and states, often serve as the basis for data collection and reporting, making them more accessible and standardized for comparison and analysis.

Given its agricultural focus, the transition analyses concentrate on the combined zone of a landscape, where most farming occurs. The landscape agricultural area is thus defined as the combination of all on-farm land in a landscape. It is essential to recognize, however, that all zones play a vital role in the transformation and should be transitioned in parallel, as they are interdependent.

The extent to which the agricultural area in the combined zone is accounted for in the modelling varies for each selected landscape, depending on the amount of land used by the selected agricultural products in each region and the relevance of other crops in the landscape.

- Querência city/BRAZIL: Entire agricultural area
- Punjab state/INDIA: Entire agricultural area
- North Dakota state/USA: Food crops net farming area (40% of agricultural area)
- Easter of England region/UK: Potato farming area (4% of agricultural area)
- Waikato region/NEW ZEALAND: Entire agricultural area
- Murang'a county/KENYA: Entire agricultural area

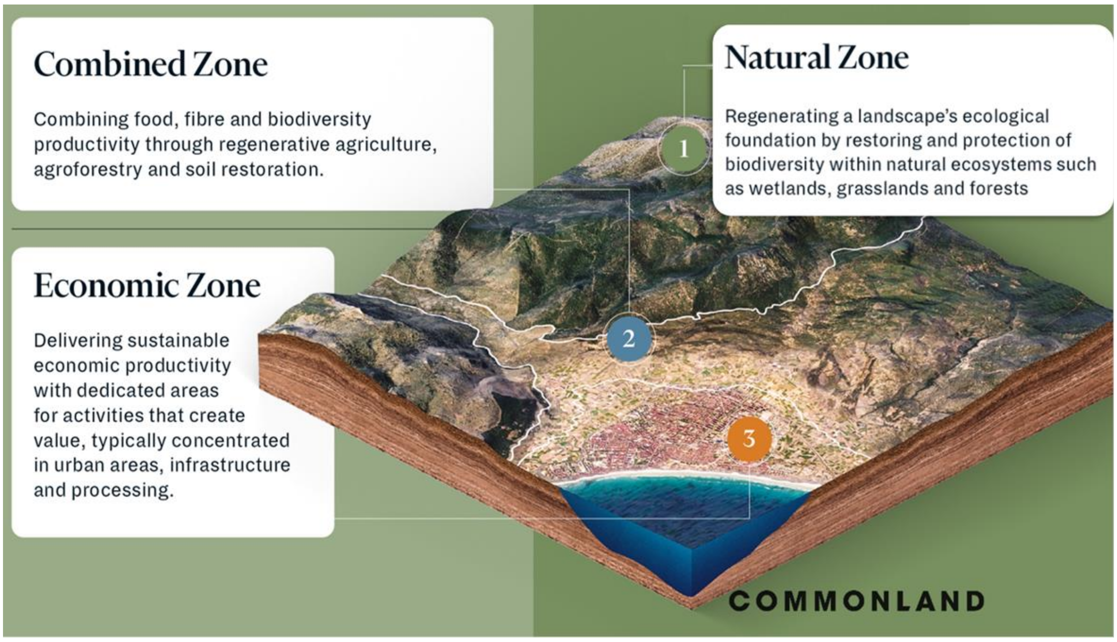


Figure 2- Terrestrial Landscape Zones. Source: Commonland

LANDSCAPE ASSESSMENT

To define a potential future state for an agricultural landscape and chart its transition pathway, it was first necessary to assess its current state comprehensively. This evaluation focused on key aspects such as land use, farm archetypes, agronomic practices, and the specific challenges faced within the landscape. These challenges were examined across economic, social, and environmental dimensions to ensure a holistic understanding, consistent with the Regen10 Outcomes Framework. By establishing a detailed baseline, the analysis could identify critical gaps, opportunities, and priorities that would inform the design of the transitions.

Land cover

Land cover in the agricultural landscape was assessed using publicly available databases, primarily provided by local or national administrative bodies. This data was cross-referenced with satellite data to determine and confirm:

- Size of agricultural area
- Area currently dedicated to the planting and harvesting of each crop throughout seasons.
- Trends in land-use change (when historical data was available)
- Livestock types and density
- Existence of areas that needed legal restauration e.g. forest reserve deficits or degraded riparian margins within farmland.

The sources for the data are listed in the reference's session of each transition case.

Archetypes

For each landscape up to two archetypes were defined to account for different key characteristics in farm distribution and land-use within the hole landscape, such as farm size, and production systems (predominant farming practices and portfolio).

The criteria for archetype selection were as follow[1]:

- In landscapes with minor differences in both production systems and farm sizes, a single archetype to represent the entire landscape is selected.
- In landscapes with minor differences between production systems but significant differences in farm size distribution, two farms of different sizes but with the same production system were selected.
- In landscapes where farm size differences are either not significant or less relevant, and there are notable differences in production systems, two archetypes representing farms of similar size but with different production systems are chosen.

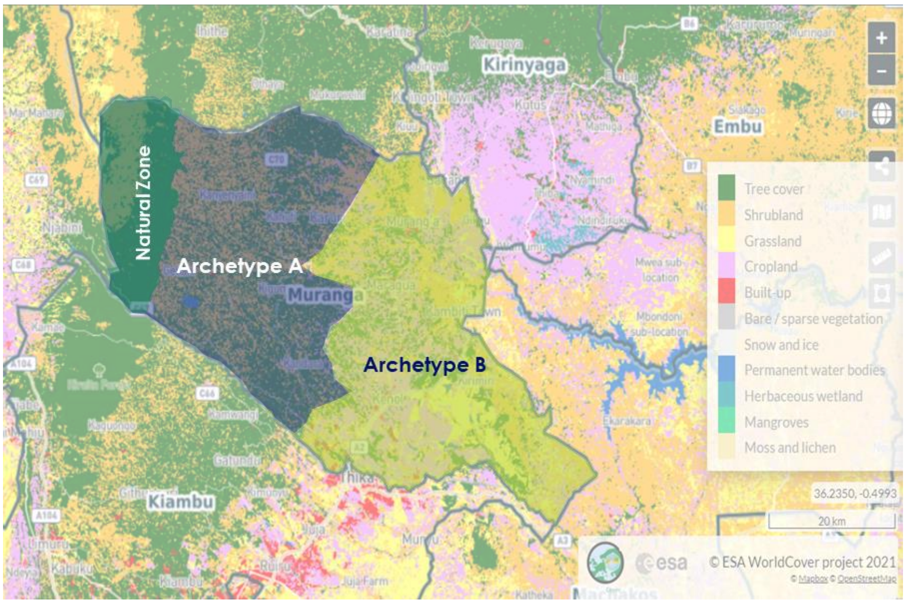


Figure 3 – Example of archetype selection for Murang'a County in Kenya, in which farm size distribution is uniform but production portfolios vary within the landscape. Source: ESA WorldCover project

Agronomic practices

The agronomic farming practices predominant for each archetype within the landscape were assessed based on literature and expert consultations. This evaluation provided an overview of the various methods currently employed across the production of different agricultural products, particularly the ones in focus for each landscape, e.g. Rice in Punjab.

Challenges

Pressing ecological, social, and economic challenges for each landscape were assessed, in line with the outcomes outlined in the Regen10 landscape framework. This evaluation focused mainly on challenges related to or deriving from agriculture and land use, which could potentially or partially be addressed by an agricultural transition to regenerative practices.

[1] Source: Agribenchmark, 2005, A Standard Operating Procedure (SOP) to define Typical Farms

2. Develop a methodology for estimating the costs and benefits of a transition that can be applied to different landscapes.

Model structure

The basic model is developed to allow application across different landscapes and to cope with the format and expected limitations of available data, particularly from secondary sources. However, the specificities of each transition (e.g., current and future land use, number and type of agricultural products, heterogeneity in farm distribution, etc.) and the availability of information on how regenerative practices take effect over time can result in significant tailoring to the basic structure.

The model is designed to start with the current agricultural characteristics for the selected landscape. This definition should entail a geospatially bounded area for each crop and livestock, which jointly form the area under analysis, together with the farm distribution and prevailing farming practices.

From this starting point, we can derive the landscape archetypes. The archetype is an aggregation of spatially distinct crop groups and animal rearing practices for farms of a specific size. (ref. Landscape Assessment for archetype definitions). While the model assumes that each crop group occupies a discrete area, we recognise that in practice farms will have overlapping and continuous area of planting. The model's representation should not have a significant effect on the results as we assume practical equivalence when aggregated in one landscape unit.

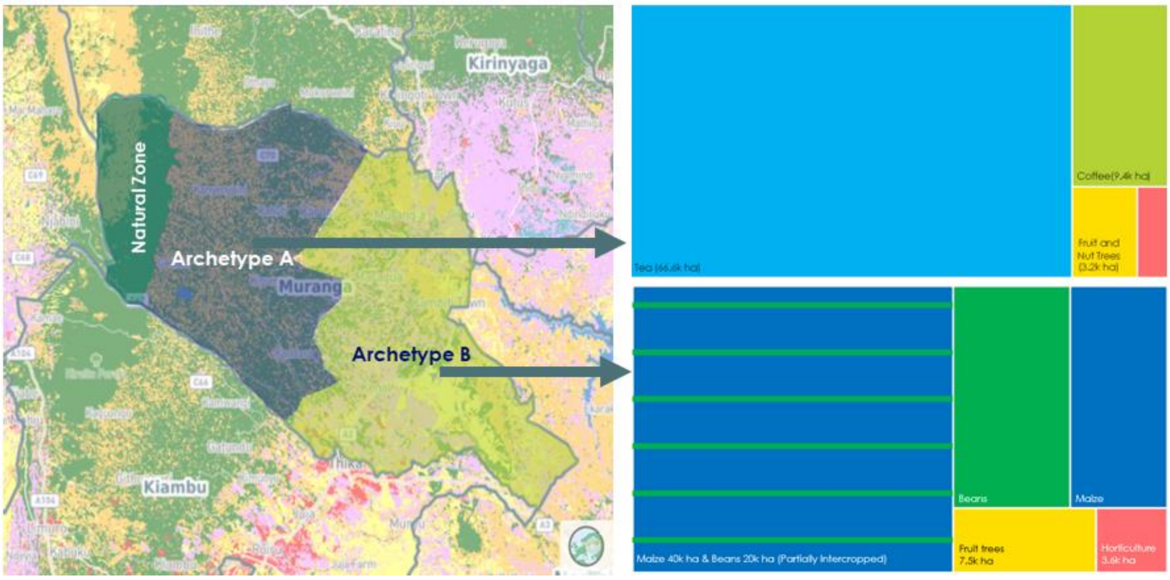


Figure 4 – Land currently used by distinct crop groups for different archetypes in Muranga, in which farm size distribution is uniform but production portfolios vary within the landscape.

Income statements are produced for each relevant crop and livestock within the landscape archetype. These statements detail the current gross revenues, operating costs, and net profits for each agricultural product, expressed in monetary units per area (e.g., USD/hectare).

Income statements are produced by product because most data are organized this way. Farmers, especially in commercial settings, evaluate their economic results based on each product's contribution. Notably, segmenting by product presents challenges in attributing and dividing overhead costs and investments, such as labour, farm infrastructure, and financial costs, which can apply to the entire farm. To address this, farm-wide costs that cannot be attributed to a specific crop or livestock are proportionally divided among the different products based on the proportion of their land cover and the typical farm size for the archetype.

The land-use area and income statements for each crop and livestock are aggregated to determine the current revenue, costs, and profitability of the landscape archetype. This is achieved by multiplying the proportional area occupied by each agricultural product with the economic units of each crop and livestock for the archetype. For example, if coffee occupies 30,000 hectares of a total 100,000 hectares of agricultural land and yields a net profit of 1,000 $ per hectare, coffee's contribution to the current profitability will be (30,000/100,000) * 1,000 $/hectare = 300 $/hectare.

The proportional revenues, costs and profits of multiple agricultural products are summed to obtain the current economic outcomes for the archetype. To allow for a comparison between current and future states that better isolates the effects of the adopted regenerative interventions, the current results, given in $/area, are assumed to remain fixed for the entire transition period.

A similar process is developed to obtain the economic outcomes of the future state for the selected archetype, which can them be compared with the results from current state to estimate the costs and benefits of the transition.

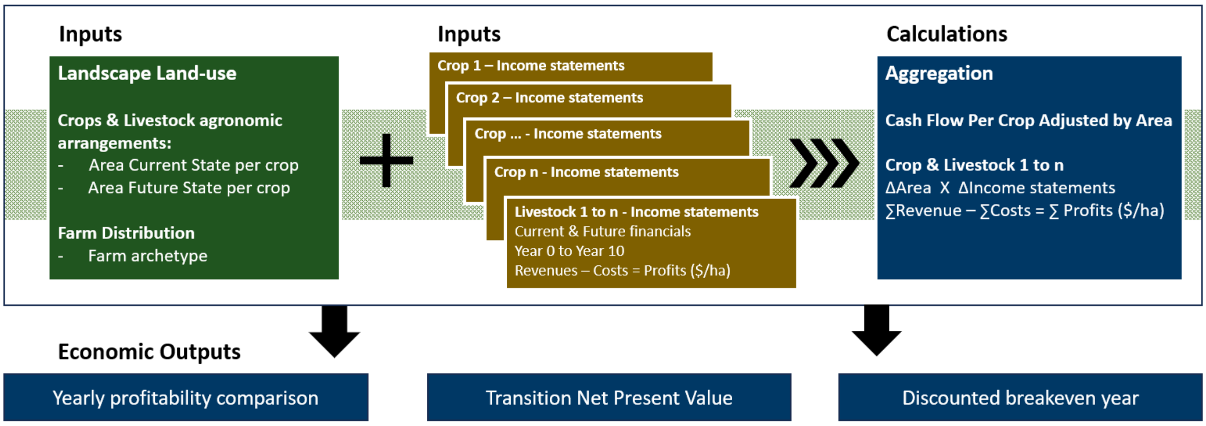


Figure 5 - Model basic structure for each archetype.

Once the outputs for an archetype have been calculated, the model aggregates these archetypes back into a single landscape. This is done by multiplication of economic units of each archetype with the area of such units in the landscape.

3. Define a desired future state for the landscape after 10 years, incorporating context-appropriate regenerative agricultural interventions.

There is no single formula to determine what the future state of the landscape should look like. This state was determined qualitatively, balancing ambition with the feasibility of what could be potentially achieved in a relatively short span of 10 years. We applied regenerative agricultural principles and context-relevant practices to seek desired outcomes that could address some of the challenges identified during the landscape assessment, using the Regen10 farm and landscape-level outcomes framework as a starting point.

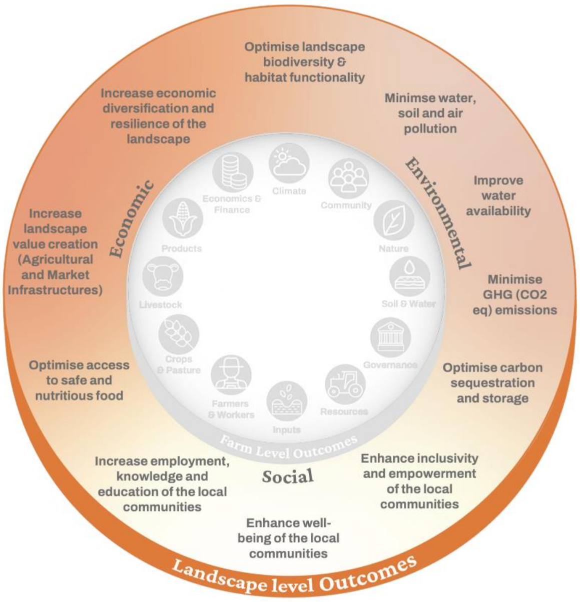


Figure 6 - Regen10 landscape level outcomes.
Source: Regen10 Zero-Draft Outcomes Framework

The experiences and emerging results from regenerative agriculture pioneers—whether farmers, landscape initiatives, or local agricultural research organizations (e.g., EMBRAPA in Brazil, NDSU in North Dakota, or Punjab University in Punjab)—formed the basis for defining and refining the transition hypothesis for each landscape. We focused on selecting agronomic interventions proven to work in the specific conditions of each landscape, avoiding to the possible extent unwanted environmental collateral effects. Despite the increasing availability of studies and data, there is still a significant need for broader evidence linking practices and outcomes, which underscores the importance of developing an outcomes-based framework in the likes of Regen10`s one.

Growing crops	Managing livestock	Designing landscapes
▪ No or minimum tillage ▪ Cover crops ▪ Longer, more diverse crop rotations ▪ Ley farming ▪ Inter-cropping or polycultures ▪ Retaining crop residues on soil ▪ Applying compost, manure, other biological soil amendments ▪ Using integrated pest management to minimise pesticides ▪ Reducing or eliminating synthetic fertilisers ▪ Better irrigation management (e.g. for rice)	▪ Raising livestock on pasture for whole life ▪ Mob grazing / adaptive multi-paddock grazing / holistic grazing techniques ▪ Integrating grazing animals into crop rotations and orchard management ▪ Avoiding hormones & antibiotics **Integrating trees** ▪ Planting trees on cropland (agroforestry) ▪ Planting trees on pasture (silvo-pasture) ▪ Mulching pruning residues and old trees in orchards	▪ Shelterbelts ▪ Hedgerows ▪ Pollination strips ▪ Riparian area restoration ▪ Water conservation through landscaping (e.g. keyline) ▪ Managing non-productive areas for ecological goals

Figure 7- Non-exhaustive list of regenerative agricultural practices that can be applied to the transitions.
Source: McMahon, P. 2024, Investing in Regenerative Agriculture Reflections from the Past Decade

To further guide the interventions, policy analysis looks at land-use or practice adoption rules. For example, farmers might need to keep native reserves on their land or be banned from burning crop residues. It also considers existing government plans for the landscapes or broader regions, like reducing land for water-intensive crops by a certain amount.

The transitions involved are:

- **Change in production area**. This involves changes in the area allocated for specific agricultural products, e.g. the area initially designated for coffee is replaced with horticulture.
- **Change in production practices.** This involves the application of context-relevant regenerative agricultural practices to each of the crops or livestock on the landscape archetype, e.g. maize monoculture is intercropped with beans and rotated with soy.

The selected transition pathways hypothesis for the landscape are supported by literature review and historical trends of changes in management practices and tested and aligned with Regen10 and other experts.

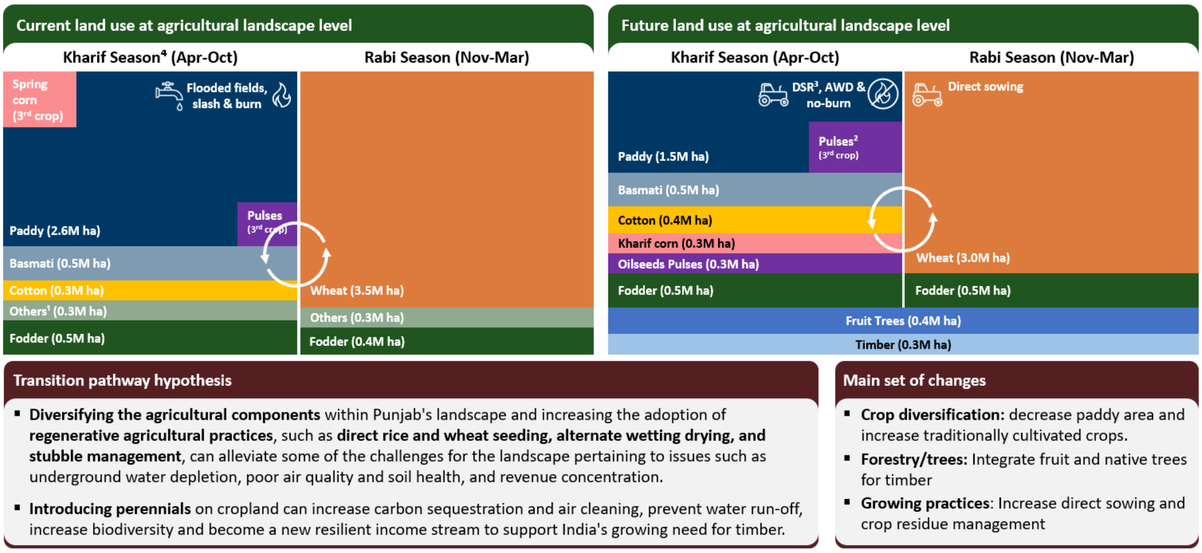


Figure 8 - Example of transition pathway hypothesis for Punjab.

Once the areas and future practices are identified, transitions are broken down into 10-year economic calculations for each crop and livestock. These calculations consider the required interventions and their impact on revenues, costs, and necessary on-farm investments.

To model the future income statements for each product, we rely on several key assumptions. These assumptions are essential for creating a feasible analysis but come with inherent trade-offs and limitations. They provide a structured framework to predict economic outcomes, acknowledging that real-world variability and unforeseen factors may impact the actual results. Below are some of the main assumptions guiding our economic analysis:

- A successful transition starting in Year 1 for the entire landscape, with farmers willing to implement regenerative practices and finding required technical and financial support to execute them.
- Constant farm gate prices and maintenance of existing subsidy schemes.
- Disregard for the effects of inflation on prices and costs throughout the projected period.
- Existence of market links for farm offers and needs, including increased volumes or new products, with buyers and suppliers available for trade.
- The existence of arrangements for external livestock to graze on crop residues or cover crops through local agreements or grazing exchange platforms.

- Yield variations (upwards and downwards) are based on available studies for the landscape or similar agroecological regions in the country where specific data is not available. If there is no evidence of the practice's impact on income statements, but there is evidence of environmental benefits, the practice is included in the transition. Its implementation and maintenance costs are accounted for, without further impact on costs and revenues.
- Capital costs and payment terms as per national practices, varying from one to eight years. When capital costs e.g., bank loan rates, could not be specified, the national interest rate was used as proxy.
- Investments in new regenerative agricultural equipment are cost per farm, based on typical farm sizes. In landscapes where lending and sharing schemes for regenerative agriculture machinery are available, these options are selected for smaller holders.
- The agronomic changes are assumed to be on-farm or paid by farmers, ensuring costs and benefits are reflected in profit and loss. Landscape-level interventions funded by others, such as the government or market actors, are excluded to avoid distortions.
- Exclusion of potential revenues from non-agricultural products or offers other than existing public subsidies, such as carbon, price premiums, payment for ecosystem services, grants, and increases in land value.

4. Estimate and compare the current and future farming profits (cash flows) of the transitions over a decade.

When the economic outcomes of the current and future states are obtained for each agricultural product, the model aggregates them according to the area designated to each crop and livestock. The results, shown in USD/ha, are compiled to indicate:

- **Yearly comparison between current and future states in nominal terms:**
  - How the landscape-level farming revenues, costs and profits change over the 10-year transition period.
  - How the future profitability compares to the current one throughout the period.
  - The profits forgone by farmers during the transition period in USD/ha and in USD/farm, using typical farm size for the landscape archetype.
  - The year when future profits exceed current profits in nominal terms (breakeven year)

Breakeven year:	5	`year when future profits exceed current profits in nominal terms
% Change in profits:	51%	difference between Future and Current profits at year 10 of the transiiton
Profit forgone (USD/ha):	-3,597	Potential profits farmers forgo before breakeven during the transition (on average, in nominal terms)
Profit forgone (USD/Farm)	-287,771	Potential profits the archetype farm forgo before breakeven during the transition (in nominal terms)

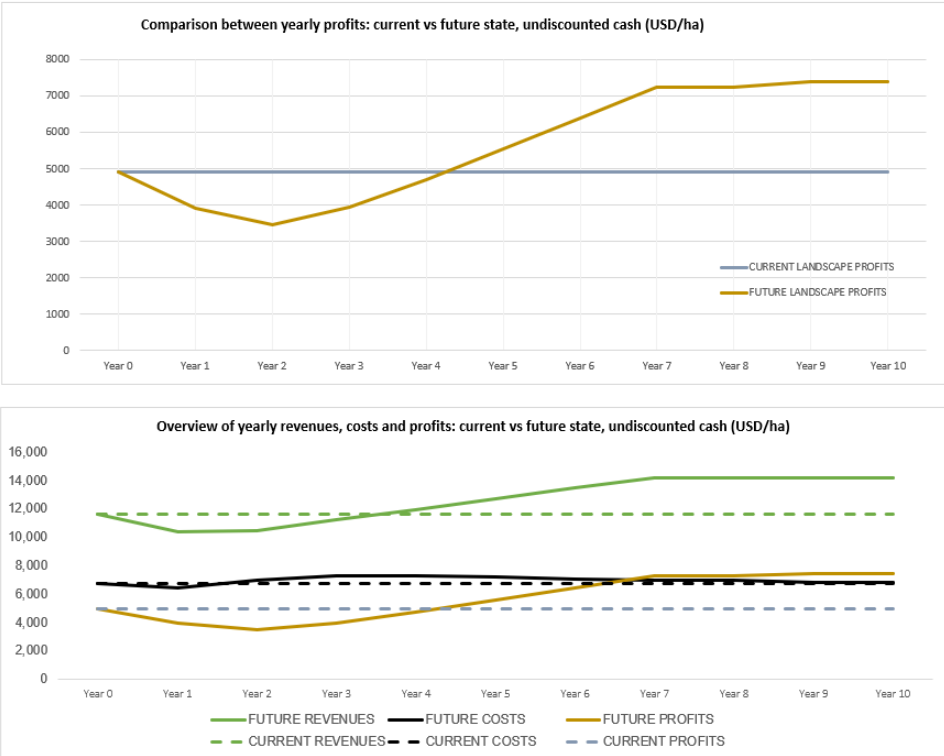


Figure 9 - Illustrative example of yearly comparison between current and future states in nominal terms

- **Financial attractiveness of the transition using net present value (NPV)**
  - The net present value (NPV) of the net change in profits during the transition (USD/ha). Calculated by subtracting the NPV of the sum of current profits (years 1 to 10) from the NPV of the sum of future profits (years 1 to 10).
  - The net present value (NPV) of the transition for the landscape (USD). Calculated by multiplying the NPV of the net change in profits during the transition (USD/ha) by the total area of the landscape (ha).
  - Indication of the contribution from changes in revenues and costs to the net change in profits at the future state.
  - The year in which the accumulated future profits (year 1 to 10) surpass the accumulated current profits (year q to 10), accounting for the time value of money (Discounted breakeven year).

To ensure a straightforward comparison across different transition pathways, we adopted a flat discount rate of 10% for calculating the net present value (NPV) of transitions. While market-based discount rates vary by geography, this standardized approach simplifies the analysis. However, it is important to note that this uniform rate may have influenced the perceived attractiveness of some results, depending on how local discount rates compare to the 10% rate used in our study.

DISCOUNT RATE	10%			
Net Present Value of Transition:	2,605	USD/ha		
Net Present Value of Transition:	208,384,414	USD for Agricultural Landscape	Discounted Breakeven year:	10

Figure 10 - Illustrative example net present value graphics and figures for the transition.

5. Estimate qualitatively the environmental and social outcomes deriving from the envisioned transition.

This analysis focuses on the economics of transitioning to regenerative practices at a landscape level. However, it is essential to recognize that a fully regenerative transition must account for social and environmental outcomes in addition to economic ones.

A qualitative assessment of these expected outcomes is performed against the metrics and indicators of the zero-draft version of the Regen10 Outcome Landscape Level Framework (Figure 6) to estimate the potential implications of the agronomic changes for the landscape. This assessment also serves as a double-check, allowing us to revise the transition hypothesis if any of the outcomes show a significant decline.

The expected changes in the outcomes are indicated directionally, ranging from neutral (no significant change) to negative or positive. The intensity of the change is measured on a five-point scale:

- **Negative** (The majority of indicators and metrics are expected to decrease with the transition)
- **Neutral-Negative** (Less than half of the indicators are expected to be negative, but none are positive)
- **Neutral** (Indicators and metrics are mixed or no changes are expected)
- **Neutral-Positive (**Less than half of the indicators are expected to be positive, but none are negative)

- **Positive** (The majority of indicators and metrics are expected to increase with the transition)

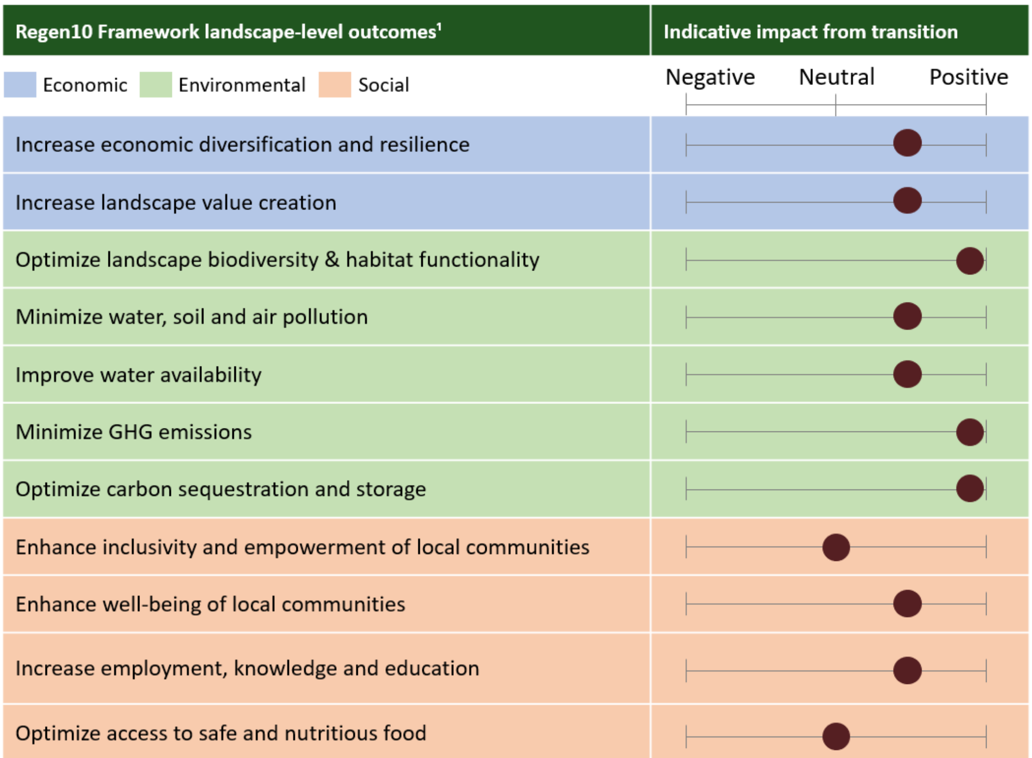


Figure 11 – Illustration of qualitative assessment against Regen10 landscape-level outcomes framework for Punjab.

A revised set of outcomes and the list of accompanying indicators and metrics for the Regen10 landscape-level outcomes framework are expected to be published following the current revision and testing period.

Discussion and limitations of the analysis

The limitations of the method presented in this paper fall into three categories: those relating to the modelling approach; to the data available; and to the generalisability and validity of the resulting conclusions. The most important limitation is the data availability and the limited evidence of the links between the application of regenerative practices in a landscape and on specific crops grown at a landscape and the economic, environmental and social outcomes of these practices over time.

1. **Limitations to the data:**
   a) **Limited evidence on regenerative practices outcomes.** The effectiveness of regenerative practices can vary significantly depending on local conditions. This variability means that results from one region or farm may not be applicable to another, complicating the aggregation of evidence. Many studies on regenerative practices are also short-term, which may not capture the full range of benefits or potential drawbacks that emerge over longer periods. Long-term data is crucial for understanding the sustainability and scalability of these practices and their impact throughout the transition period. Much of the existing research is concentrated in high-income countries, and in landscapes where research institutions e.g. universities, extension services, etc. are active, with limited data from low- and middle-income regions where regenerative practices might have different outcomes due to varying socio-economic and environmental conditions.
   b) **Quality and availability of agronomic and economic data.** While data on land cover and use is more readily available from satellite imagery and jurisdictional databases, economic and agronomic data are much more location specific and vary widely in quality, accuracy and timeliness. The model developed here relies on local data being available to provide a level of insight that is not available from global datasets; this is not equally true everywhere.
   c) **Sources of bias in the data.** Data collection methods in many countries introduce bias towards larger, commercial farmers against smallholders; preferentially capture the activities and attitudes of men over those of women and youth; and imply a 'legibility' and permanence of land holdings, use and production that may not correspond with local reality. They are also more readily available for goods that are traded and taxed than those that are grown for subsistence. As a result, the findings may be biased towards the larger, more commercial operations in a landscape.

2. **Limitations of the modelling approach**
   a) **Implementation approach.** To allow for a clearer comparison between current and future profits during a relatively short period, the model assumes regenerative practices across all the crops and farms on the landscape are successfully implemented from year 1 of the transition. This sudden approach obscures the financial constraints, technical challenges and labor and equipment shortages associated with a change of such magnitude. It is likely, instead, that most of the adoption of regenerative practices in farms will happen gradually, with farmers first experimenting with new techniques and crops in small plots before scaling or with few pioneer farmers leading the way and being followed by others once results and transition resources e.g., capital and technical support, start to further materialize.
   b) **Approach to capital and market constraints**. We acknowledge that farmers face significant capital constraints, and do not assume that investments in context-

relevant regenerative agriculture practices can be fully funded from retained earnings or paid by third parties such as a government or NGO. Instead, we assume borrowing options are readily available for farmers at market rates and payment terms varying from 1 to 8 years. To diversify land use and revenue sources, the production mix of some landscapes has been altered. In some cases, the production volumes of certain agricultural products have been significantly amplified. The diversification options have been limited to those that are known to be suitable for the climatic conditions of the region and for which there is already an existing or potential market. Off-farm investments in adjusting market infrastructure to accommodate the new and increased flow of production, such as silos, transportation, and packaging, have only been accounted for in cases where part of the pre or post-harvest processing needs to be done on-farm due to the complete absence of value chain links.

c) **Geographic boundaries**. The transition of the landscapes was confined to the on-farm area so cost and benefits for farmers could be highlighted. A full landscape transition, however, also requires investments and transformations outside the farm boundaries and that encompasses the entire combined zone (agricultural area) as well as the economic zone (urban areas) and the natural zone (natural ecosystems).

d) **Unforeseen ecological implications.** While this study quantitatively assesses the potential economic impacts of new agricultural practices, it is important to acknowledge the limitations in predicting unforeseen ecological implications. The complex interactions between these practices and the existing landscape cannot be fully foreseen or calculated within the scope of this research. As a result, there may be unexpected ecological outcomes that arise from the introduction of these practices.

3. Internal and external validity

a) **Internal validity within the landscape.** In some landscapes, e.g., Murang'a, farm management models are relatively uniform, with small size, family ownership and limited mechanization in common. In others, e.g., Punjab, there is a wider range of holding and parcel sizes, management methods, the level of mechanization and technology more broadly. The more diverse the landscape and farm archetypes within it, the harder it is to generalize from the analysis.
b) **External validity outside the landscape.** With the selected landscapes covering a minimal portion of Earth's cultivated area, it is not possible to claim global applicability of the insights from this work. Rather, it should be taken as an illustration of what is possible in particular circumstances, and a validation and qualification of the landscape approach.

Data sources

The data sources and key specific assumptions are provided at the references page and in the footnotes of each case.