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A case study on the practice of Ethnoveterinary Medicine in India in the context of Nature Positive Food Systems

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1. Introduction

Transforming food systems to be more nature-positive requires actions that both minimise harming the environment and actively contribute to biodiversity restoration and enhancement. Given the food system's complexity — including environmental impacts, social dynamics, technological processes, infrastructure, and institutional frameworks — a shift towards nature-positive food systems (NPFS) requires a collaborative, multi-stakeholder approach.

To deepen our understanding of the NPFS concept and the transition toward such systems across diverse spatial, environmental, social/cultural, and economic contexts, two agricultural practices were selected as case studies: one in Kenya and another in India. In this report, we focus on India, specifically the use of ethnoveterinary medicine (EVM) among smallholder dairy farmers in Anand, a district in Gujarat state, India (figure 1).

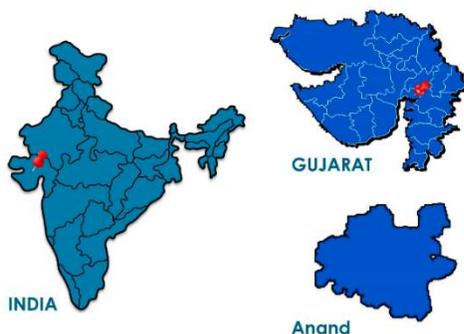


Figure 1: The case study site Gujarat state in India (left pin), Anand district of Gujarat state (top right pin) and the Anand district (right bottom), Gujarat, India. (Map from the Center for One Health Education, Research & Development (COHERD), Indian Institute of Public Health, India)

During a field visit we engaged with key stakeholders like researchers, small holder farmers, managers of dairy cooperatives and community representatives. Through a series of interviews and focused group discussions, we gathered insights into their perception of NPFS, the enablers and barriers they encounter and important performance indicators for a nature positive food system.

EVM involves traditional animal healthcare practices including the use of medicinal plants, spiritual healing, and manual therapies, which are rooted in the cultural beliefs and ecological knowledge of local communities [1]. EVM is also referred to as ethnoveterinary practices (EVP). EVM considers that traditional practices of veterinary medicine are legitimate and seeks to validate them. These practices,

based on a deep understanding of local ecosystems and animal behaviors, make them particularly relevant for their potential benefits as sustainable and accessible veterinary care, especially in rural and resource-limited settings.

This case study is part of the activities carried out in the project Nature Positive Food Systems under the KB35 program Food and Water Security, of Wageningen University and Research, funded by the Ministry of Agriculture, Fisheries, Food Security and Nature.

2. Case study

2.1. Aim

This research explored how dairy farming stakeholders perceive and engage with EVM within the context of nature positive food systems (NPFS). EVM involves traditional animal healthcare practices including the use of medicinal plants, spiritual healing, and manual therapies, which are rooted in the cultural beliefs and ecological knowledge of local communities in Anand, Gujarat [1]. These practices, based on a deep understanding of local ecosystems and animal behaviors, make them relevant for their potential benefits in sustainable and accessible veterinary care, especially in rural and resource-limited settings.

Our primary goal was to delve into the diverse perspectives of these stakeholders on EVM, examining not only its current application but also identifying the necessary support and improvements required to transform agricultural practices towards nature positive food systems.

2.2. Description

India is the world's largest milk producer, contributing to 23% of the global production [1, 2]. Most of the milk and dairy products produced are also consumed within the country [3]. Notably, about 95% of Indian milk producers are small-scale farmers with herds ranging from 1 to 5 animals but collectively contributing 62% to the country's total milk production [4].

Keeping livestock is a major livelihood for many farmers in India, with about 70% of rural communities said to rely on it as their main source of income [4]. However, for the farmers interviewed during the field visit, dairy farming serves as a secondary source of income, following production of crops, like wheat and millet. In India, nearly 70% of the work in dairying is done by women [5]. During the field visit, four of the five farmers interviewed, were women.

The state of Gujarat produces approximately 7.5% of the country's milk [3]. Anand, a city in the state of Gujarat, is known as the Milk Capital of India. Amongst others, this city hosts the National Dairy Development Board (NDDB), and the Head Office of Gujarat Cooperative Milk Marketing Federation Ltd (AMUL). During the field visit we were hosted by the NDDB, and we had discussions with various employees within the organisation (not all recorded as official interviews).

The NDDB is a statutory body set up by an Act of the Parliament of India. It is under the ownership of the Ministry of Fisheries, Animal Husbandry, and Dairying of the Government of India. The NDDB promotes, plans, and organizes programs for the development of dairy and other agriculture and allied industries in India.

The NDDB advocates the so-called Anand Pattern, which refers to a dairy development model. It is based on a cooperative model where farmers own and manage dairy processing and marketing collectively. This approach ensures that the profits from the dairy business return to the farmers themselves rather than to middlemen, or other corporations. The Anand Pattern consists of a three-tier structure consisting of the Village Society, the District Union, and the State Federation.

A village dairy cooperative society (DCS), under the Anand Pattern, is formed by milk producers and dairy farmers, who join by purchasing a share and committing to sell their milk to the society, regardless of the quantity. Each DCS operates a milk collection center where members deliver their daily surplus, beyond what their families consume. The quality of each member's milk is assessed based on fat content and solids-not-fat (SNF) levels, with payments made accordingly. At the end of each year, a portion of the DCS profits is distributed among members as a patronage bonus, which is proportional to the volume of milk provided.

The District Milk Union purchases all the milk collected by DCS and then handles the processing and marketing of milk and dairy products. In addition, most Milk Unions provide various forms of support to their DCS members, including veterinary care and artificial insemination, to promote continuous growth of milk production and the cooperative's overall business.

During our field visit in Gujarat, we visited various role players involved in the Anand Pattern, and we spoke with stakeholders in the dairy industry who have knowledge of, or experience in, using EVM.

The Sabar Milk Union has more than 1500 DCS with 300,000 farmers belonging to them. Most farmers belonging to this union own water and land and have an average of 5-6 cows. These marginal farmers produce about 3,200,000 liters of milk per day ("32 lak"). About 1,200 farmers are called progressive farmers, meaning they have over 20 cows. Approximately 145 veterinarians are working for the union.

Approximately 30% of India's milk is produced by crossbreeds [6]. The introduction of the crossbreeding of indigenous cattle with exotic breeds, like Holsteins and Jerseys, was initially mainly aimed at enhancing milk production levels. However, the high incidence of diseases in these cross-bred animals, potentially exacerbated by insufficient management and feeding systems, leads to an increase in health problems and subsequently the indiscriminate use of antibiotics and other veterinary drugs. Ultimately high antibiotic use in dairy animals leads to high antibiotic residues in animal products, like milk, which is not only a concern for the general health of the consumer, but also contributes to the global health concern of the development of antimicrobial resistance (AMR).

Furthermore, the high need for veterinary drugs adds to the treatment costs of cattle, thereby decreasing the income of the farmer.

To combat the one health concern accompanied by the high use of conventional veterinary drugs, the Indian dairy industry has made good progress in understanding and promoting the use of EVM, based on Ayurvedic principles. The alternative medicine system of Ayurveda, which dates to 2000 BC, has its historical roots in the Indian subcontinent and is still used for human ailments today.

The NDDDB launched its Mastitis Control Popularisation Program (MCP) in 2014. This was aimed at combating the high incidence of mastitis in dairy cattle. Within two years the use of EVM was incorporated into the program. Since 2016 the NDDDB, in conjunction with the Center for Ethno-Veterinary Science and Practice, of The University of Trans-Disciplinary Health Sciences and Technology in Bengaluru (TDU), records, assesses, validates, and promotes the use of EVM. This is done under the scientific leadership of emeritus professors Nair and Punniyamurthy, who also accompanied us on the field visit. Within this program milk union leaders and farmers are taught how to use EVM formulations for various ailments of dairy cattle.

The NDDDB has already developed teaching material (brochures and video clips) for treating more than 20 ailments commonly encountered by dairy farmers. These materials, containing precise EVM formulations, are freely accessible and available in all the major vernacular languages in the country.



Figure 2: An animal technician at Sabar Dairy mixing a mastitis remedy, using a ready-made mixture as basis.

To further enhance the use of EVM, ready-made formulations are prepared, packaged, and sold to dairy farmers through milk unions and private companies. During the fieldwork, we visited a production facility of these formulations at Sabar Dairy (Gujarat), which collaborates closely with the NDDDB. The EVM formulations prepared here are sold to farmers belonging to the milk unions in this area, at a cost price. These herbal alternatives, used to prevent and cure disease conditions in cattle (**Figure 2**), give farmers immediate access to veterinary care and save their expenditure on livestock health management, a major motivation for dairy farmers to use EVM. It is the goal of this initiative to reduce drug residues in food and the environment.

During our field visit, we gathered the perspectives of various stakeholders in the dairy industry of the Anand region regarding their views on nature and nature-positive practices, with a particular emphasis on EVM. In this study, EVM is regarded as a practice with the potential to promote nature-positivity by reducing the environmental impact linked to the use of antibiotics.

3. Methodology

We adopted a qualitative approach, utilizing the landscape canvas methodology as a framework to design interview questions. This approach was further supported by previous work from the Nature Positive Food Systems (NPFS) project, including the definition of nature positive food system, the list of indicators, and the analysis of enablers and barriers for NPFS. The methodology facilitated the collection of insights from various stakeholders on the implementation of EVM among dairy farmers in Anand and their views on how this practice intersects with nature.

3.1. Stakeholders

For the study, we targeted individuals and organizations engaged in, or influencing dairy farming and/or EVM in the region. This included:

- Dairy farmers
- Representatives from the National Development Dairy Board (NDDB)
- Researchers from the University of Trans-Disciplinary Health Sciences and Technology (TDU)
- Experts from the local nature conservation institute, Foundation for Ecological Security (FES)
- A well-known and experienced journalist, active in nature-related and socio-economic topics

3.2. Data collection

3.2.1. Interviews

Most of the data collection in this study was carried out via structured interviews with stakeholders. The interview questions were organized around seven areas, based on the developed NPFS landscape canvas. An overview of these areas, along with their specific focus points, is presented in **Table 1**.

Stakeholders were divided into three groups: farmers (including the DCS representatives), academia (including a local journalist who has been working with the University for many years), and institutions (representatives of nature conservation and the NDDB). A specific set of questions was tailor-made for each stakeholder group to explore the areas identified within the landscape canvas framework.

To specifically address Area 7 in the Canvas (**Table 1**), which focuses on defining success, we introduced a set of cards featuring pre-selected key performance indicators (KPIs) (**Table 2**) detailed

in **appendix A to E**. These KPIs were grouped into four categories: i) biodiversity and nature, ii) land use and productivity, iii) environment and climate, and iv) socio-economic aspects. Farmers were asked to select the factors they considered essential for their farming practice to be nature positive, regardless of their current situation. For the researchers and nature conservation representatives, the focus was on choosing indicators to evaluate whether a system is nature positive, or not.

A translator was needed to facilitate the interviews with farmers and DCS members, and this support was provided by a representative of the NDDB.

3.2.2. Focus group discussion

After conducting the interviews, we organized a focus group discussion (FGD) that included four representatives of the NDDB and two researchers from TDU. During this session, we introduced the definition of nature positive food systems, as was developed in this project, and asked the group's opinion on the definition. The working definition was: "We refer to nature positive food systems as food systems that have nature at the heart of decision-making and that will lead to increased biodiversity and improved ecosystem functioning through collective understanding and action." We further explored aspects related to Area 2 of the canvas, which had not been explicitly addressed until this stage. This discussion also covered methodologies for assessing whether a food system or practice is nature positive. Additionally, we delved into the specific synergies and trade-offs of EVM, as perceived by the group.

Table 1. Overview of the different sections in the landscape canvas and their focus

Area	Focus
1. Nature positive	To explore definitions and perceptions of nature and stakeholders' conceptualizations of nature and the place of humans within it.
2. Nature Positive Food Systems	To gather views on the concept of NPFS and its relevance to their agricultural practices.
3. Why? (Motivation)	To identify the reasons behind the implementation of EVP, as an example of a nature-positive practice, among farmers.
4. What is needed?	To get insights into the needs, enablers, and barriers to the implementation of nature positive practices such as EVP.
5. Who is needed?	To examine the support systems, actors and networks, essential for supporting EVP and broader nature positive (NP) agricultural practices.

6. How?	To explore effective instruments, motivations, synergies, and compromises for broadening or transitioning to EVP and, overall, more NP practices.
7. What is success?	To record how stakeholders would measure the impact of the agricultural practice.

Table 2. Key performance indicators (KPIs) selected in nature positive food production systems

Category	Selected KPIs
Biodiversity and Nature	<ul style="list-style-type: none"> • Water quality • Water availability • Diversity of animals & plants • Diversity of crops & livestock
Land use and productivity	<ul style="list-style-type: none"> • Productivity & yield from agriculture • Soil quality • Land use for agriculture vs conserved land • Land use for agriculture vs urban areas • Well-being of the cattle
Environment and Climate	<ul style="list-style-type: none"> • Pesticide use • Veterinary drug use • Fertilizer use • Manure use • Resilience of the food system against CC • kg CO₂-eq/ha
Social and economic	<ul style="list-style-type: none"> • Access to healthcare • Access to agricultural extension service • Ownership of the land • Income security • Price received per product • Resilient & sustainable livelihood • Social equity • Gender equity

3.2.3. Ethical considerations

Ethical approval for the interviews and group discussion was granted by the WUR Research Ethics Committee (approval number: 2024-15).

Before conducting any interviews, participants were given the approved project information sheet, which included an overview of the project and our contact details for any follow-up questions. Also,

the project was introduced to TDU and NDDDB representatives through email and discussions before the field visit. At the beginning of each interview, we read a consent form to the interviewees and obtained their oral consent to proceed.

4. Results and Discussion

To aid in understanding the contributions and perspectives of each interviewed stakeholder, **Table 3** provides an overview of their background.

Table 3. Overview of stakeholder background information

Stakeholder	Gender	Role/Background	Note
Farmer 1	Male	Chief of farmers in a village. The DCS in this village consists of about 150 farmers.	
Farmer 2	Female	Housewife, manages cattle (4 water buffaloes), and oversees family-owned land rented for crop production with profit sharing.	
Group of farmers	Female	Responsible for household and cattle, related and living adjacent to each other. The women own between 3-11 cows.	Crop production is mainly handled by men.
Biodynamic farmer	Male	Owens 40 acres of land and has practiced biodynamic farming for 20 years.	Focus on crop production; owns more than 10 crossbreed cows, not practicing EVM.
NDDDB representative	Male	Veterinarian, working at NDDDB's.	Specializes in animal health and antimicrobial resistance (AMR) challenges.
Researcher	Male	Professor in clinical veterinary pharmacology.	Promoting EVM.
FES representatives	Female & Male	Employees of the Foundation for Ecological Security.	https://www.fes.org.in/
Journalist	Female	Journalist, podcaster, public speaker, BBC news anchor.	Focuses on socio-economic issues, and EVM initiatives in India and the Netherlands.

4.1. Nature and Nature Positive

Table 4. Stakeholders' point of view on what is nature and when is a practice nature positive

Stakeholder	Point of view
Farmers	<p>Farmer 1</p> <p>Sees nature as unbalanced, acknowledging the challenges posed by climate change.</p> <p>Agrees that humans are a part of nature and believes in the goodness of organic farming but does not practice it himself.</p> <p>Nature can be improved by planting more trees and using less plastics, also reducing cattle's consumption of plastic and carbon emissions.</p> <p>Farmer 2</p> <p>Describes nature in spiritual terms as God, encompassing surroundings and all living things.</p> <p>Sees pollution as detrimental to nature. This farmer acknowledges the use of fertilizer and pesticides but recognizes the tension between the effects of these products on environmental health and financial motivations for farming, e.g., higher crop yield.</p> <p>Group of female farmers</p> <p>Define nature as the essentials: fresh air, water, and light. In their view, humans are part of nature.</p> <p>Feel that the immediate environment is healthy due to the absence of factories and pollution. However, they worry about the future impacts of fertilizers and pesticides on nature.</p> <p>Biodynamic farmer</p> <p>After adopting biodynamic farming, he started seeing nature as an interconnected unit that includes animals, plants, and humans.</p> <p>Emphasizes that nature offers daily lessons on adaptation and responding to climate change.</p> <p>Has ceased using pesticides, valuing the symbiotic relationship among all creatures. This farmer mentioned that before becoming a biodynamic practice the farm experienced the harmful impacts of chemical fertilizers and pesticides, including human and cattle poisoning seen due to pesticide application—crop yields also declined, and pests increased.</p>

NDDB	<p>For the interviewee plants are the first element that comes to mind when considering nature. Humans are seen as an integral part of nature.</p> <p>The interviewee shares a positive view regarding the health of nature, citing that a significant majority of the population in India lives rurally and is engaged in nurturing nature.</p> <p>Water is highlighted as a key natural resource that is readily available, with most farms having a well, although the quality of the water is admittedly unknown.</p> <p>Nature positive actions are described as anything that does not harm nature.</p>
Researcher	<p>Nature is classified into five distinct regions in India, including forests, mountains, cultivated river regions, seashores, and desert-like regions. Nature reflects a deep-rooted system of understanding that is thousands of years old.</p> <p>Previously, humans were seen not just as living in nature, but as an integral part of it, historically evidenced by village life. However, there is a growing disconnection between humans and nature in contemporary times.</p> <p>Assessing the health of nature across India is complex due to regional diversity. Government regulations stipulate that one-third of a region's territory must be forest, which serves as a health indicator for the region. Cultivated land is perceived as separate from nature, with agro-forestry and monoculture cited as modern practices that are currently under scrutiny and subject to improvement by active groups in India.</p> <p>The researcher describes a traditional nomadic practice where farmers move with their cattle ("transhumance"), which promotes soil health. This nomadic practice is associated with nature-positive actions, particularly in maintaining ecosystem balance.</p>
FES	<p>Affirm that humans are a part of nature, with historical roots in Indian culture emphasizing a symbiotic relationship between people and the natural world.</p> <p>The interviewees note a shift away from this symbiotic past, acknowledging that modern ecology and socio-economic circumstances have actively shaped the current state of nature.</p> <p>Nature-positive actions are described as those that fortify the symbiotic relationship between forests, agriculture, water, and humans.</p>
Journalist	<p>Acknowledges that there is a significant focus on being positive to nature within communities, highlighting a deep respect and reverence for nature.</p> <p>Nature positivity, as well as the success of environmental measures, can be difficult to quantify and measure, especially given the vast geographical area of India.</p> <p>Urbanization is identified as a big barrier to nature positivity.</p>

4.2. Nature Positive Food Systems – definition

The actual term "Nature Positive Food Systems" was first introduced for discussion during the focus group session. Participants noted that in the Indian context, NPFS is deeply intertwined with religious beliefs and traditions, which can vary significantly, even among individuals within the same village.

In Gujarat, animal-derived products such as milk, curd, and ghee are considered staple foods, with their taste varying by region, due to different production methods. The participants acknowledged that food systems encompass all aspects of food production, processing, and consumption, and are dynamic, influenced by factors such as seasonal availability, affordability, and religious practices. Furthermore, human health and economic factors play significant roles in shaping these systems.

A concern raised during the discussion was the increasing consumer demand for year-round availability of all food products, which exerts pressure on the food system. Participants further expressed that the natural connection between food and health, once prevalent in older generations, seems to have diminished among younger people, who are more susceptible to commercial influences; they often consume more processed foods.

When asked whether the members of the group consider their food system to be healthy and nature positive, the consensus was that it is not. The reasons cited included non-seasonal production, the wide use of pesticides, artificial ripening agents and hormones, and the introduction of foreign species, all of which have adverse effects on nature and contribute to soil depletion. Specifically, the use of pesticides was linked to a decrease in biodiversity, with a notable impact on bee populations.

4.3. Why? – motivation and practice-based interpretations

Table 5. Summary of stakeholders' motivations for adopting, or not adopting, EVM as an example of a nature positive practice.

Stakeholder	Point of view
Farmers	<p>Farmer 1</p> <p>Observed positive effects of EVM on the reduction of mastitis cases among livestock, which also fostered a sense of independence among farmers, as they could now administer immediate treatment without waiting for a veterinarian.</p> <p>Farmer 2</p> <p>The initiative to adopt EVM was spearheaded by the village committee of DCS, with the Milk Union playing a crucial role in providing guidance and advice.</p> <p>The trust placed in the livestock inspector from the veterinary extension service was a significant factor in the farmers' decision to implement EVM.</p> <p>The farmer believes that EVM is beneficial for nature, emphasizing that the use of natural ingredients, sourced directly from the environment, contributes positively to ecological well-being.</p> <p>Group of female farmers</p> <p>EVM is viewed as inherently good for animals because the treatments are derived from nature.</p> <p>The implementation of EVM has led to improved animal health, i.e., reduction of mastitis cases, and increased milk production.</p> <p>Biodynamic farmer</p>

	Only implements EVM if/when the veterinarian from the extension service recommends that.
NDDB	<p>Since the introduction of the EVM program in 2016, about 40% of farmers in the broader Anand-area have adopted these practices. Several factors have contributed to their implementation:</p> <ul style="list-style-type: none"> • EVM is viewed as a sustainable practice because it does not harm/destroy the plants. • There has been a reduction in antibiotic use, which can also be beneficial to preserving soil health.
Researcher	<p>EVM has been linked to financial and clinical success in the region.</p> <p>The lack of access to conventional animal care services presents EVM as a viable alternative.</p> <p>There is a lesser impact on nature; most of the kitchen supply suffices for producing the required herbal remedies, reducing the need for extensive resource consumption.</p> <p>The collection of herbs is conducted with consideration for the safety, availability, and sustainable use of plant parts to promote environmental conservation.</p> <p>EVM is an eco-friendly practice, as it does not use synthetic chemicals. Additionally, the practice promotes the linking of environmental conservation with practical utility, empowering individuals to start and maintain home herbal gardens with ease, further enhancing the practice's sustainability.</p>
FES	The interviewees were not familiar with the term EVM and did not reflect on the potential impact of this practice on nature.
Journalist	<p>Engagement in events at various universities and a congress as moderator showing the accomplishments and knowledge associated with EVM.</p> <p>She advocates for greater dissemination and recognition of EVM's value, seeking to leverage academic platforms and media engagement.</p>

4.4. What and Who is needed

4.4.1. Enablers, barriers, condition

The interviews revealed several enablers and barriers that influence the successful adoption of EVM in Anand. These include:

Enablers:

- The Anand Pattern has facilitated the spread adoption of EVM, with farmers trusting the expertise of the livestock inspectors and relying on their guidance. Milk Union, specifically Sabar Milk Union, supplies farmers with ready-to-use herbal products, which are favored due to their ease of preparation and trusted efficacy. This immediate availability of affordable treatment options reduces the wait for veterinary services and allows farmers to manage their herds' health independently.

- The support and training provided by the NDDDB programs are very important, encouraging farmers to adopt EVM more broadly and to experiment with new plant recipes. This has also led to more consistent success rates.
- NDDDB members highlighted an increasing consumer preference for milk from cows not treated with antibiotics, which promotes the use of EVM over conventional treatments.

Barriers:

- The dependency on the Milk Union's structure could pose a barrier to implementing EVM in other areas where such support is absent.
- A significant barrier is the lack of awareness and understanding of EVM, compounded by the loss of traditional knowledge over generations. To counteract this, educational initiatives are essential. For instance, the integration of EVM into the veterinary science curriculum at universities, as mentioned by a professor during our interviews, is a positive step.
- Production pressures frequently emerged as a barrier, where farmers feel compelled to use less nature positive alternatives to meet product demands. While all interviewed farmers had only small numbers of cattle or buffalo, it remains unclear whether managing larger herds would also pose a barrier to the practical use of EVM.

4.4.2. Stakeholders and their role

The growth of EVM in Anand is largely driven by the support and leadership of key organizations, including NDDDB, Milk Union, and TDU. Additionally, the DCS plays a crucial role, supported by the dedication of individuals within the supply chain who are committed to show the benefits of EVM.

A notable obstacle identified is the absence of institutional backing. The journalist argues that increased budgetary allocations are crucial for giving EVM the necessary momentum. A critical gap highlighted is the lack of investment in knowledge transfer mechanisms for EVM. The journalist emphasizes the need for a clear, apolitical path or system that facilitates the dissemination of EVM knowledge.

4.5. How - tools, synergies and trade-offs

During the interviews, it became clear that training is a valuable tool to ensure the success and motivation of implementing EVM in a region and access to ready-to-use herbal products. Piloting and dissemination of successful cases is also a key factor for growth and motivation. Furthermore, the positive effect EVM has on the net income of the farmer and the successful outcome of treatment, should be broader disseminated. Another important incentive is that EVM gives farmers independence in the primary health care for their animals.

The farmers we interviewed did not report any trade-offs in the implementation of EVM. However, their strong reliance on a single institution to provide the supplies and knowledge needed to

implement EVM could pose risks, such as limited access to alternative resources, reduced autonomy in decision-making, and vulnerability to institutional changes. This dependence may also restrict knowledge diversity, hindering their ability to adapt to evolving challenges in agricultural practices and market conditions. Regarding the crop production in the area, pesticides are a big trade-off to produce sufficient and market-acceptable produce. Many of the interviewees indicated that they realize that this is not friendly to their environment and that they would want to not use it, but they also feel they cannot stop using it, as this would reduce the quantity and perceived quality of their products.

Important synergies are the collaboration between the extension services and the milk union. The Anand Pattern and the support of the NDDDB enable the success of EVM in the region.

A very important synergy in this case study is that an affordable animal healthcare system with a high success rate (as perceived by the users), could lead to a healthier environment (nature).

4.6. What is success? - key performance indicators

Table 6 to 9 give an overview of the indicators selected by the interviewed stakeholders during the field study and also give insights into what they consider successes. While we did not request the stakeholders to rank the indicators, some of them did indicate the order or relationship among the indicators during their selection process.

Additionally, during the focus group discussion (FGD), we addressed how the success of agricultural practice should be measured, particularly in terms of assessing a food system's nature positivity. The group acknowledged that the definition of nature positivity might vary across different regions, which could influence the measurement criteria. The group emphasized that success cannot be measured with just a few cases; meaningful assessment requires substantial data and variety across multiple locations and under different conditions to ensure the practice's effectiveness.

Education was identified as a crucial factor in determining the success of a system. Awareness of the negative impacts of certain practices is essential for motivating change. The group identified the following criteria to measure the success of the EVM practice:

1. Animal health.
2. Prevalence of antibiotic resistance.
3. Biodiversity.

Biodiversity was a focal point during the discussion, with the group stressing the importance of understanding the broader implications of human activities. It was emphasized that conventional veterinary drugs often lead to unintended environmental consequences. For example, vultures face fatal poisoning by consuming livestock carcasses treated with the painkiller diclofenac. In contrast, EVM was highlighted for its minimal environmental impact, as it avoids leaving harmful residues like

painkillers and antibiotics in the environment. It is however imported to harvest the botanicals used for EVM in a sustainable manner; this is typically done by using only specific parts of a plant, rather than the entire plant.

Despite these environmental benefits, the group recognised that financial motivation remains a significant driver for farmers. For a food system to shift towards being more nature-positive, it must offer tangible benefits to farmers and producers. The cost of implementing EVP has decreased over time in Gujarat, mainly due to the continual improvements within the system and sustainability of these practices.

Add a paragraph after all the tables with a matrix with stakeholders as rows and indicators as columns and crosses which ones were selected. Then reflect on this selection in chapter 7.

Table 6. Stakeholder choices for biodiversity and nature KPI's

Stakeholder	Biodiversity & Nature	Comments
Farmers group		
Farmer 1 (male)	<ul style="list-style-type: none"> Water quality Water availability Diversity of animals & plants Diversity of crops & livestock 	KPIs are correlated; water is alive; water is very important; everything is dependent on each other
Farmer 2 (female)	<ul style="list-style-type: none"> Water availability 	
Group of female farmers	<ul style="list-style-type: none"> Water quality Diversity of crops & livestock 	If water quality is good, all can survive. If water and food are healthy, people can survive
Biodynamic farmer (male)	<ul style="list-style-type: none"> Water quality 	If there is no water the rest can't be met
Academia		
Researcher 1	<ul style="list-style-type: none"> Diversity of crops & livestock Diversity of animals & plants 	
Institutions		
NDDB (representative)	<ul style="list-style-type: none"> Diversity of animals & plants 	
MRIDA (representative)	<ul style="list-style-type: none"> Diversity of crops & livestock 	

FES (two representatives)	<ul style="list-style-type: none"> • Water availability • Diversity of animals & plants • Water quality 	<p>People in some areas are noticing changes in water's taste if there is a change in quality</p> <p>There is a need to measure water quality to bring action</p>
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Table 7. Stakeholder choices for land use and productivity KPI's

Stakeholder	Land use and productivity	Comments
Farmers group		
Farmer 1 (male)	<ul style="list-style-type: none"> • Soil quality • Productivity & yield from agriculture • Land use for agriculture vs urban areas 	<p>Soil quality is good, and as long as it stays good, we will have good productivity.</p> <p>No more concrete, i.e. less urban areas</p>
Farmer 2 (female)	<ul style="list-style-type: none"> • Productivity & yield from agriculture 	
Group of female farmers	<ul style="list-style-type: none"> • Soil quality 	
Biodynamic farmer (male)	<ul style="list-style-type: none"> • Soil quality 	(The most important)
Academia		
Researcher 1	<ul style="list-style-type: none"> • Soil quality • Land use for agriculture vs conserved land • Well-being of the cattle • 	The well-being of the cattle and soil quality are more practical to measure.
Institutions		
NDDB (representative)	<ul style="list-style-type: none"> • Land use for agriculture vs conserved land 	
MRIDA (representative)	<ul style="list-style-type: none"> • Soil quality 	
FES (two representatives)	<ul style="list-style-type: none"> • Soil quality • Well-being of the cattle • Productivity & yield from agriculture • Land use for agriculture vs conserved land 	<p>The well-being of the cattle including goats and sheep</p> <p>It should be 'Land use for agriculture, including conserved land' and not versus.</p> <p>The vision is not to create segregated conservation spaces such as designated parks, but have a model where people have access to natural resources but utilize them conservatively,</p>

implying a sustainable use model that integrates human needs with environmental stewardship.

Table 8. Stakeholder choices for environment and climate KPI's

Stakeholder	Environment & climate	Comments
Farmers group		
Farmer 1 (male)	Should be reduced <ul style="list-style-type: none"> • Pesticide use • Veterinary drug use • Fertilizer use • kg CO₂-eq/ha Important <ul style="list-style-type: none"> • Manure use • Resilience of the food system against CC 	
Farmer 2 (female)	<ul style="list-style-type: none"> • Manure use (good for nature) • Pesticide use (should not be used) 	
Group of female farmers	<ul style="list-style-type: none"> • Manure use These should be reduced: <ul style="list-style-type: none"> • Pesticide use • Fertilizer use • kg CO₂-eq/ha 	Manure good for nature
Biodynamic farmer (male)	<ul style="list-style-type: none"> • Manure use • Resilience of the food system against CC 	
Academia		
Researcher 1	<ul style="list-style-type: none"> • Manure use Avoid as much as possible <ul style="list-style-type: none"> • Pesticide use • Veterinary drug use 	Manure usage>>how much of that is practical
Institutions		
NDDB (representative)	<ul style="list-style-type: none"> • Manure use • Veterinary drug use Resilience of the food system against CC	

MRIDA (representative)	<ul style="list-style-type: none"> • Manure use (from farmers perspectives) • Pesticide use (compulsory by government) • Fertilizer use (compulsory by government) • kg CO₂-eq/ha 	"CO ₂ emissions would not be something that farmers think about. Maybe later."
FES (two representatives)	<ul style="list-style-type: none"> • Pesticide use • Fertilizer use • Manure use Resilience of the food system against CC	How Resilience of the FS against CC will be measured? Manure usage is considered a very important indicator.

Table 9. Stakeholder choices for social and economic KPI's

Stakeholder	Social & Economic	Comments
Farmers group		
Farmer 1 (male)	<ul style="list-style-type: none"> • Access to health care • Price received per product 	"If we are healthy, we can work. And for all the rest of the cards we need money"
Farmer 2 (female)	<ul style="list-style-type: none"> • Access to healthcare • Resilient & sustainable livelihood 	
Group of female farmers	<ul style="list-style-type: none"> • Access to health care • Gender equity • Income security • Social equity • Price received per product 	The consensus among the women was that gender equity is not possible if income security is not fulfilled. <ul style="list-style-type: none"> • Money crisis leads to gender inequity.
Biodynamic farmer (male)	<ul style="list-style-type: none"> • Resilient & sustainable livelihood • Social equity • Access to healthcare • Access to agricultural extension service 	"Access to healthcare is important but if the rest is good the access to health care is not needed".
Academia		
Researcher 1	<ul style="list-style-type: none"> • Gender equity • Social equity 	"All the KPI's are connected despite the interest of individual farmers".

	<ul style="list-style-type: none"> Resilient & sustainable livelihood Price received per product Access to healthcare 	
Institutions		
NDDB (representative)	<ul style="list-style-type: none"> Resilient & sustainable livelihood 	
MRIDA (representative)	<ul style="list-style-type: none"> Resilient & sustainable livelihood Income security 	
FES (two representatives)	<ul style="list-style-type: none"> Gender equity Social equity should be seen together Ownership of the land Resilient & sustainable livelihood 	Gender and social equity should be seen together

5. Additional insights from the interviews

5.1. NDDB

5.1.1. Agricultural Landscape and Practices

- The region of Anand is heavily utilized for agriculture, occupying 70-80% of the area, excluding the city.
- Land ownership among farmers is prevalent, indicating a potential personal investment in land stewardship.
- A variety of crops are cultivated, including bananas, tobacco (mainly for exportation), rice, flowers (also for exportation), and crops for cattle feed, revealing a diverse agricultural economy supplying both domestic and international markets.

5.1.2. Sustainability Concerns

- Pesticides are selectively used on certain crops, suggesting an awareness of the impact of these substances on the environment.
- Organic fertilizers are employed by some farmers, driven by market demands, product quality and consumer behaviors, which indicate an economic incentive for sustainable practices.
- A notable practice among farmers is the rotation of tobacco and banana crops to maintain soil health.

5.1.3. Policy and Regulation Gaps

- The absence of a policy for handling manure or the use of sustainable fertilizer is recognised, indicating an area where development and regulation could support nature positive initiatives.

5.2. Foundation for Ecological Security (FES)

The FES works in 14 states and more than 45000 villages. Their activities are partly sponsored by the government, but also by private donors.

5.2.1. Impacts of farming on nature

The conservation representatives recognize the negative impacts of certain agricultural practices, such as the loss of tree plantations leading to reduced populations of bees and birds like crows. Fencing is also mentioned as having a detrimental effect on biodiversity.

The use of non-biodegradable chemicals, such as tetrazine and other pesticides, is highlighted as a significant concern, pointing to the persistence of these substances in the environment and their broad impact. However, there is an acknowledgment of improvement in areas where communities take ownership, hinting at the effectiveness of community-led conservation efforts.

5.2.2. Biodiversity concerns and community action

There has been a noticeable decline in some species, specifically the crow, which could be a broader indicator of ecological shifts. On a positive note, the increased collective action of communities to conserve resources, including water, is seen as a hopeful sign. The importance of the FES in advising these community efforts is acknowledged, illustrating the importance of knowledge sharing and expert guidance in conservation initiatives.

5.2.3. Water quality and water availability

The use of groundwater for irrigation over the last 20 to 30 years has been identified as a contributing factor to groundwater depletion in India. Although in the Anand area depletion is not currently considered a major issue, there have been changes in water availability. Agricultural practices, specifically irrigation, need to be re-evaluated and managed to prevent further depletion of water sources. The representatives from FES acknowledged the presence of high fluoride contamination in water, which is a significant health concern. Water quality, particularly regarding fluoride levels, is not being measured with rigor. Also, during the interview with the journalist water quality emerged as a significant area of concern. Specifically, there is a mention of arsenic contamination in the water in Eastern Patel, indicating regional water pollution issues. The journalist expresses disappointment despite ongoing efforts by organizations to test and improve water quality.

Based on the importance of water that emerged throughout the interviews, a topic such as groundwater depletion might be an aspect of future studies.

5.3. MRIDA

We also discussed the activities of the NDDB in the region, with a senior employee of the company Mrida (not following the official interview questions). Mrida is a fertilizer and biogas producing company, established as another NDDB initiative. The company was established in July 2022 and has already installed almost 600 mini-biogas systems on smallholder dairy farms in the Anand area. The local (Gujarat) government subsidizes 30 to 50% of the costs. NDDB is a non-profit organization, and any profits of this company are also distributed back to the farmers. In this way, the system further improves the socio-economic situation of the farmers belonging to the union.

The name Mrida means soil, and the long-term vision of the company's activities is to increase soil health. Biogas is not a new concept in India but establishing it for private household use is a new initiative. Mrida installs biogas production systems for households and provides them with training and support. The units have a 5-year maintenance plan.

The clients of Mrida are mainly women. Their households do not only benefit financially from this system, but the system also saves the working women time, for example from having to collect firewood. Without these systems (i.e. originally) farmers had to let the manure from their cattle ferment in a pit for 6 to 8 months before they could use it on their fields. Now they can use the slurry within 35 days and produce enough gas for electricity and cooking for their households.

Manure from non-landowners and excess manure from landowners are bought by the company and used in the centralized manure management plant, where the biogas produced is used to run the dairy production plant in Anand. The fertilizer produced at this plant is sold as organic fertilizer (after processing it to meet governmental standards). Organic fertilizer is better for soil health than chemical fertilizer and leads to carbon enrichment.

5.4. Sabar Milk Union

During a discussion with a senior employee of the Sabar production plant, we asked him about the effects he has seen from EVM in the region. He explained that they have been working on the Mastitis project since 2014. The focus was particularly on curing chronic mastitis cases. In the beginning, progress was slow as the preparation of the herbal remedies and their application required a lot of time. The confidence in EVP was low and farmers were used to treating cows with antibiotics. It was very difficult to convince veterinarians of the value of EVM, as it wasn't taught in veterinary schools. EVM also requires extra work for the veterinarian (versus for example giving one injection of a long-acting antibiotic).

Sabar Milk Union initially started with advocating EVM in 50 villages. They paid a local villager to promote and then also document the use of EVM. Due to the good results seen and high recovery

rates, EVM expanded. A first study showed a more than 92 % cure* rate without antibiotics, in 1000 cases treated. (**We did not study the published scientific papers and are not sure what cure entails for specific cases (clinical, vs microbial; and return rate)*)

Sabar now manufactures ethnoveterinary products and makes them available to dairy societies. They further disseminate information to the farmers through the DCS. The ready-to-use products are largely subsidized, and the price is managed by the union. The farmers pay a small fee.

According to the interviewee, such a program can only work with the farmers if someone takes the lead. A motivator for this program should be to decrease antibiotic residues in milk and AMR and improve human health. The farmers save money as conventional mastitis treatment is costly. The region has now seen a 60 %* reduction in antibiotics used, as well as a decrease in mastitis cases. Milk production has also increased.

Since the start of the mastitis program, the EVM focus of SABAR has widened to, for example, preventive treatment after purchasing new cattle (to increase immunity). Last year a recipe was also used in a Lumpy skin outbreak. NDDB and Sabar does however still advocate the vaccination of cattle.

5.4.1. Crossbreeding practices

The intent behind crossbreeding local Indian cattle breeds with European high-producing cattle breeds was to increase milk production, but it also had negative consequences. The recommendation now is that exotic genes should not exceed 60% in crossbred animals, to maintain adaptability to the Indian climate and reduce health problems caused by environmental and dietary mismatches. Traditional practices of good local breed selection are largely lost.

5.4.2. Animal husbandry insights

Buffaloes are noted for having a smaller carbon footprint than cattle and better feed conversion rates, but they face challenges with fertility and behavior, especially in domesticated settings. One of the researchers interviewed suggested that effective EVM could potentially enhance buffalo fertility and make them a more viable option again.

Goats are less common in Gujarat, primarily because there is a lower demand for goat milk among Indian consumers, though they are kept by transhuman communities.

6. Research team's perceptions and study limitations

While conducting the study, our research team acknowledged several limitations that may have influenced the outcomes and interpretations of the data.

6.1. Limited number of interviewees

The study was constrained by a relatively small sample size of only nine interviewees. This limitation was primarily due to logistical challenges, including the significant distances required to travel to interview locations and the considerable time each interview demanded.

6.2. Selection bias

The predominantly positive feedback regarding EVM from the interviewees suggests the possibility of selection bias. This could mean that those who agreed to participate in the study might already have had favorable views towards EVM, thereby not representing the broader community's opinions accurately. However, our interviewees did not necessarily make an immediate connection between EVM and NPFS, i.e. their primary motivation for using EVM was not because it's considered nature positive.

6.3. Potential response bias

It was noted that some interviewees displayed hesitation to answer certain questions, especially when in the presence of other community members. This could have influenced the openness of their responses, potentially leading to data that might not fully reflect their true perspectives.

6.4. Language and translation

As the interviews were conducted in regions where English is not commonly spoken, especially with smallholder farmers, the reliance on a translator was necessary. Despite the translator's familiarity with the study's objectives, the translation process might have introduced discrepancies in interpreting the responses.

6.5. Method robustness

The study employed specific tools designed to gauge the effectiveness and perception of EVM and NPFS among different stakeholders. However, the adaptability and robustness of these tools across diverse case studies remain uncertain. India is a vast country with not only geographical and meteorological differences but also differences in practices and beliefs, policies, and regulations. This might also be true for smaller countries. This implies a need for more refined or region-specific metrics and methodologies for assessment.

7. Conclusion

This study, while not specifically aimed at assessing whether EVM aligns with Nature Positive Food Systems (NPFS) criteria, provided valuable insights that can guide the development of tailored strategies to support the transition towards NPFS. The canvas landscape provided a framework for structuring data collection and fostering conversations with stakeholders about what they consider important for nature-positive practices. Additionally, key performance indicators (KPIs) helped to frame discussions, offering a clear starting point to understand stakeholders' priorities and values. Overall, the methodology here applied allowed us to identify key strategies for implementation in the context of promoting the use of EVM as a practice with potential positive effects for achieving NPFS goals. These strategies should focus on educational programs, integrating both traditional and modern veterinary practices, improving infrastructure to address logistical challenges, and actively involving stakeholders in policymaking. Additionally, the creation of supportive regulatory frameworks will be essential to ensure the transition is inclusive, sustainable, and responsive to the diverse needs of farming communities.

Moreover, the broader implications of integrating EVM within NPFS demand the evaluation of various environmental and social-economic factors, among which are:

- Regional specificities because the food system in the Indian context needs to include people's beliefs and what they find important.
- Farmers' financial motivations (economic viability).
- The overall impact of agricultural practices on the environment. EVM is an alternative practice to reduce the use of antibiotics and other veterinary drugs. However, pesticides and chemical fertilizers are used by farmers to ensure high crop yield, and therefore income stability. This fact highlights that to support the transition towards NPFS the actions need to consider the practical and economic realities of the farming community.

Overall, a successful transition toward NPFS will require the active engagement of diverse stakeholders from various demographics and agricultural practices. The successful implementation of EVM in Anand shows the value of collaboration between farmers, institutions, and researchers, while also highlighting the need for inclusive strategies that reflect the practical realities of different farming communities. NPFS must address both environmental and socio-economic factors, ensuring that practices like EVM are sustainable and aligned with the livelihoods and priorities of these communities. Monitoring environmental impacts and safeguarding income security through indicators such as soil health, water quality, and economic returns will be essential for ensuring a successful and inclusive transition to NPFS.

8. Acknowledgements

We would like to extend our heartfelt gratitude to the National Dairy Development Board (NDDB), for sharing their knowledge and network, accompanying us in the field and hosting us – they enabled this field study.

We are also deeply thankful to Dr. Nair for his invaluable assistance in the planning and execution of this case study. His expertise and guidance were instrumental in the successful completion of this project.

Further, we would like to thank all the participating stakeholders for their time and invaluable insights. Each contribution enriched the quality and depth of this case study.

Lastly, we would like to thank the rest of our research team for their assistance in developing the methodology used in the case study and finalizing this report.

9. References

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10. Appendices

Appendix A. Canvas landscape framework to describe NPFS

Nature Positive Food Systems

What does Nature Positive mean for you?

NATURE POSITIVE

What are Nature Positive Food Systems according to you?
How do they differ from other food systems?

NATURE POSITIVE FOOD SYSTEMS

What is your motivation? Why nature positive food systems? Where do they differ?

WHY?

What conditions are needed ?

What are barriers?

What are enablers?

WHAT?

Who is needed for nature positive food systems? What motivates them?

WHO IS NEEDED?

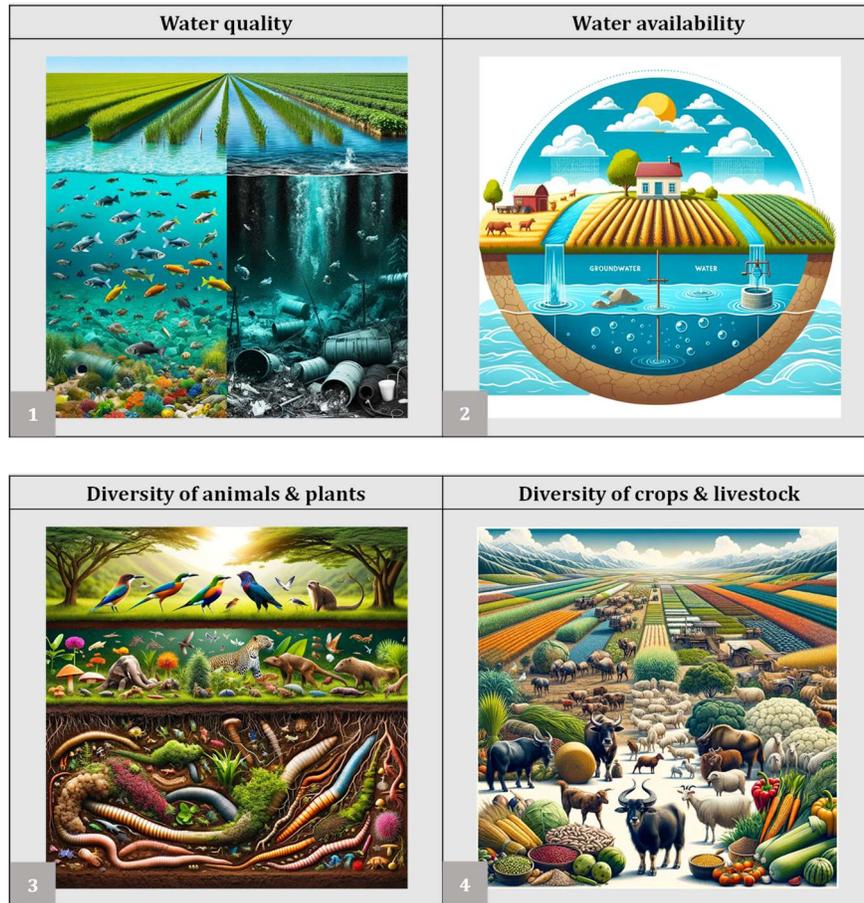
What are useful incentives and tools?	What are trade-offs?	What are synergies?
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HOW?

How does a successful nature positive system look? What things do you look at?
*Providing the list WUR defined indicators, how suitable are they?

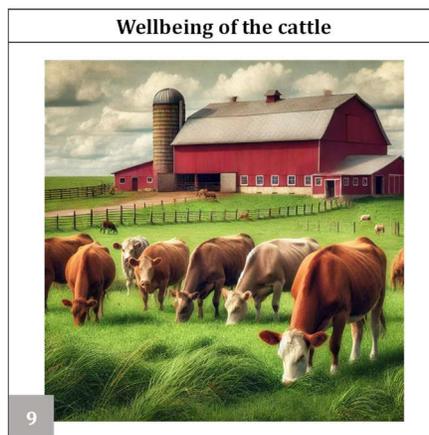
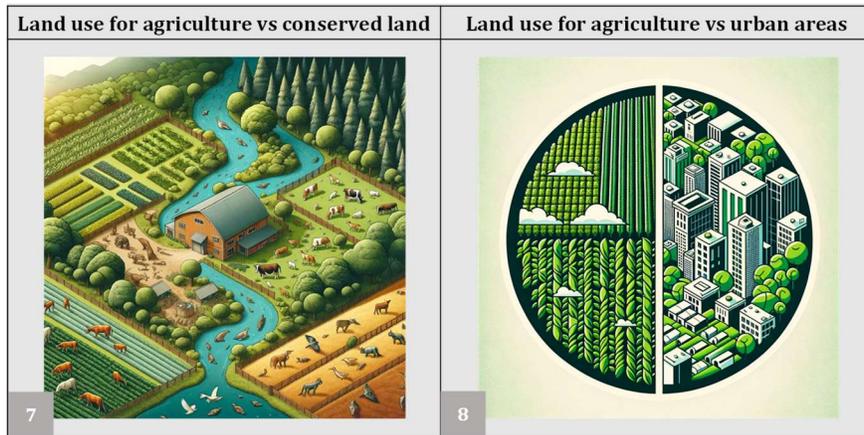
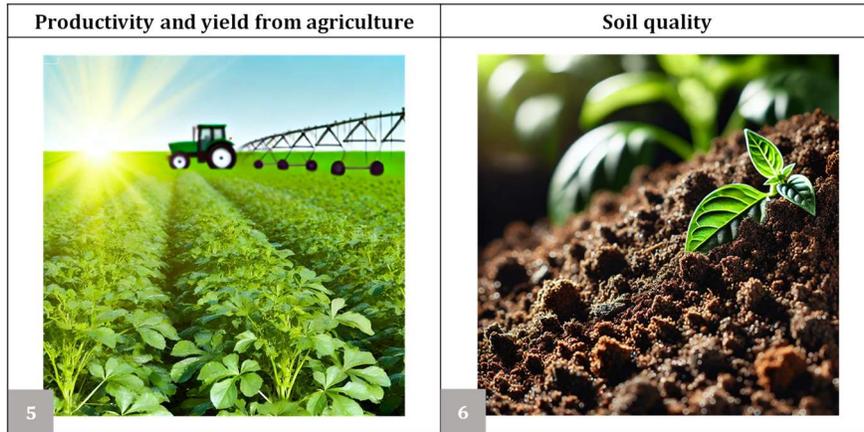
WHAT IS SUCCESS ?

Appendix B. Selected KPIs in the category Biodiversity and nature¹



¹ The figures shown in *Appendix B* were generated using artificial intelligence (AI) tools to visually represent the key performance indicators (KPIs). These AI images were meant to provide illustrative support when discussing KPIs with the stakeholders to enhance understanding and visualization.

Appendix C. Selected KPI in the category land use and productivity²



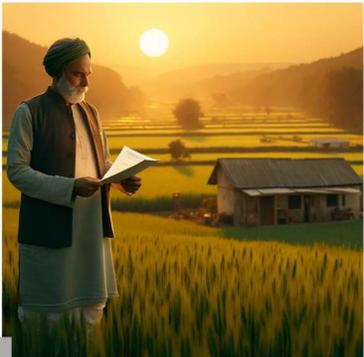
² The figures shown in *Appendix C* were generated using artificial intelligence (AI) tools to visually represent the key performance indicators (KPIs). These AI images were meant to provide illustrative support when discussing KPIs with the stakeholders to enhance understanding and visualization.

Appendix D. Selected KPI in the category land use and productivity³

<p style="text-align: center;">Pesticide use</p>  <p style="text-align: left;">10</p>	<p style="text-align: center;">Veterinary drug usage</p>  <p style="text-align: left;">11</p>
<p style="text-align: center;">Fertilizer usage</p>  <p style="text-align: left;">12</p>	<p style="text-align: center;">Manure usage</p>  <p style="text-align: left;">13</p>
<p style="text-align: center;">Resilience of the food system against CC</p>  <p style="text-align: left;">14</p>	<p style="text-align: center;">kg CO₂-eq/ha</p>  <p style="text-align: left;">15</p>

³ The figures shown in *Appendix D* were generated using artificial intelligence (AI) tools to visually represent the key performance indicators (KPIs). These AI images were meant to provide illustrative support when discussing KPIs with the stakeholders to enhance understanding and visualization.

Appendix E. Selected KPI in the category socio and economic⁴

<p style="text-align: center;">Access to healthcare</p>  <p style="text-align: left;">16</p>	<p style="text-align: center;">Access to agricultural extension service</p>  <p style="text-align: left;">17</p>
<p style="text-align: center;">Ownership of the land</p>  <p style="text-align: left;">18</p>	<p style="text-align: center;">Income security</p>  <p style="text-align: left;">19</p>
<p style="text-align: center;">Price received per product</p>  <p style="text-align: left;">20</p>	<p style="text-align: center;">Resilient & sustainable livelihood</p>  <p style="text-align: left;">21</p>

⁴ The figures shown in *Appendix E* were generated using artificial intelligence (AI) tools to visually represent the key performance indicators (KPIs). These images were meant to provide illustrative support when discussing KPIs with the stakeholders to enhance understanding and visualization.

Social equity	Gender equity
 <p>22</p>	 <p>23</p>