An Application of the Sustainable Asset Valuation (SAVi) Methodology

Assessing the economic value of restoring the wetlands of S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni in the Gulf of Oristano in Sardinia, Italy

SUMMARY OF RESULTS

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MAVA Foundation

The MAVA Foundation was established in 1994 and is a family-led, Swiss-based philanthropic foundation with offices in Switzerland and Senegal.

They work towards securing a future where biodiversity flourishes, especially in the Mediterranean, West Africa and Switzerland; the global economy supports human prosperity and a healthy planet; and the conservation community is thriving.

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An Application of the Sustainable Asset Valuation (SAVi) Methodology: Assessing the economic value of restoring the wetlands of S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni in the Gulf of Oristano in Sardinia, Italy

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Cover photo: Gianluca Furcas

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About SAVi

SAVi is a simulation service that helps governments and investors value the many risks and externalities that affect the performance of infrastructure projects.

The distinctive features of SAVi are:

- Valuation: SAVi values, in financial terms, the material environmental, social, and economic risks and externalities of infrastructure projects. These variables are ignored in traditional financial analyses.
- Simulation: SAVi combines the results of systems thinking and system dynamics simulation with project finance modelling. We engage with asset owners to identify the risks material to their infrastructure projects and then design appropriate simulation scenarios.
- Customization: SAVi is customized to individual infrastructure projects.

For more information on SAVi:

www.iisd.org/savi

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Acronyms and Abbreviations

CAP	Common Agricultural Policy
capex	capital expenditure
CLD	causal loop diagram
CO_2	carbon dioxide
ha	hectares
K	potassium
KPI	Key Performance Indicators
MEDSEA Foundation	Mediterranean Sea and Coast Foundation
MWh	megawatt hour
N	nitrogen
NGO	Non-governmental organization
O&M	operating and management
OECD	Organisation for Economic Co-operation and Development
opex	operating expense
P	phosphorus
SAVi	Sustainable Asset Valuation
SCC	social cost of carbon
tCO_2e	tonne of carbon dioxide equivalent
TIF	tax increment financing
UNEP	United Nations Environment Programme

Glossary

Causal loop diagram: A schematic representation of key indicators and variables of the system under evaluation that shows the causal connections between them and contributes to the identification of feedback loops and policy entry points.

Feedback loop: "Feedback is a process whereby an initial cause ripples through a chain of causation ultimately to re-affect itself" (Roberts et al., 1983).

Indicator: Parameters of interest to one or several stakeholders that provide information about the development of key variables in the system over time and trends that unfold under specific conditions (United Nations Environment Programme [UNEP], 2014).

Methodology: The theoretical approach(es) used for the development of different types of analysis tools and simulation models. This body of knowledge describes both the underlying assumptions used as well as qualitative and quantitative instruments for data collection and parameter estimation (UNEP, 2014).

Model transparency: The degree to which model structures and equations are accessible and allow one to directly relate model behaviour (i.e., numerical results) to specific structural components of the model (UNEP, 2014).

Model validation: The process of assessing the degree to which model behaviour (i.e., numerical results) is consistent with behaviour observed in reality (i.e., national statistics, established databases) and the evaluation of whether the developed model structure (i.e., equations) is acceptable for capturing the mechanisms underlying the system under study (UNEP, 2014).

Natural infrastructure: Natural systems that are actively managed to provide infrastructure outcomes such as managed wetlands, riparian buffers, or green roofs.

Net benefits: The cumulative amount of monetary benefits accrued across all sectors and actors over the lifetime of investments compared to the baseline, reported by an intervention scenario.

Nitrogen (N) concentration: The amount of organic and inorganic N per litre of water. N concentration can contribute to eutrophication if it exceeds a critical threshold.

Nitrogen (N) loadings: The total annual amount of N from anthropogenic wastewater, fertilizers, stormwater, and other pollution sources that reach the wetland. N loadings serve to determine the N concentration in the water.

Optimization: A stream of modelling that aims to identify the policy or set of policies that deliver the best possible outcome from a set of alternatives, given a set of criteria (i.e., parameters to optimize) and/or constraints (i.e., available budget) (UNEP, 2014).

Phosphorus (P) concentration: The amount of organic and inorganic P per litre of water. P concentration can contribute to eutrophication if it exceeds a critical threshold. This assessment uses P concentration to determine the growth of algae chlorophyll, as relevant P loadings and water recharge can be determined with relative certainty.

Phosphorus (P) loadings: The total annual amount of P from anthropogenic wastewater that reaches the wetland. P loadings serve to determine the P concentration in the water.

Scenarios: Expectations about possible future events used to analyze potential responses to these new and upcoming developments. Consequently, scenario analysis is a speculative exercise in which several future development alternatives are identified, explained, and analyzed for discussion on what may cause them and the consequences these future paths may have on our system (e.g., a country or a business).

Secchi depth: A Secchi disk is a round plate that is painted black and white. The disk is attached to a rope and lowered into the water until it is at a depth where it can no longer be seen. Secchi depth helps to measure the clarity of the water and the general "health" of the wetland.

Simulation model: Models can be regarded as systemic maps in that they are simplifications of reality that help to reduce complexity and describe, at their core, how the system works. Simulation models are quantitative by nature and can be built using one or several methodologies (UNEP, 2014).

Stock and flow variables: "A stock variable represents accumulation and is measured at one specific time. A flow variable is the rate of change of the stock and is measured over an interval of time" (UNEP, 2014).

System dynamics: A methodology developed by J. Forrester in the late 1950s (Forrester, 1961) to create descriptive models that represent the causal interconnections between key indicators and indicate their contribution to the dynamics exhibited by the system as well as to the issues being investigated. The core pillars of the system dynamics method are feedback loops, delays, and non-linearity emerging from the explicit capturing of stocks and flows. (UNEP, 2014)

Vertical/horizontal disaggregation of models: Vertically disaggregated models contain a high level of detail on the sectoral level (i.e., energy), while horizontally disaggregated models focus on capturing the interconnections between several sectors and contain less detail on the sectoral level (UNEP, 2014).

1.0 How Can Decision-Makers Use This Analysis?

Stakeholders can use this analysis to make a multitude of decisions.

- Policy-makers can use it to make decisions that integrate infrastructure planning with costal conservation, sustainable agriculture and "food systems," adaptation to changing climates, and economic development.
- Non-governmental organizations (NGOs) can use the economic valuations of ecosystem services to fine tune wetland restoration and conduct more targeted advocacy for continued conservation of the Gulf of Oristano.
- Public donors and private investors can also this analysis as a due diligence baseline for grants, concessional lending, and testing "pay-for-performance"-based financing solutions.

Details are provided in Tables 1–3 for each component of this assessment:

- Valuation approaches
- Circular business opportunities: reusing livestock manure
- Direct payments to farmers for the provision of ecosystem services

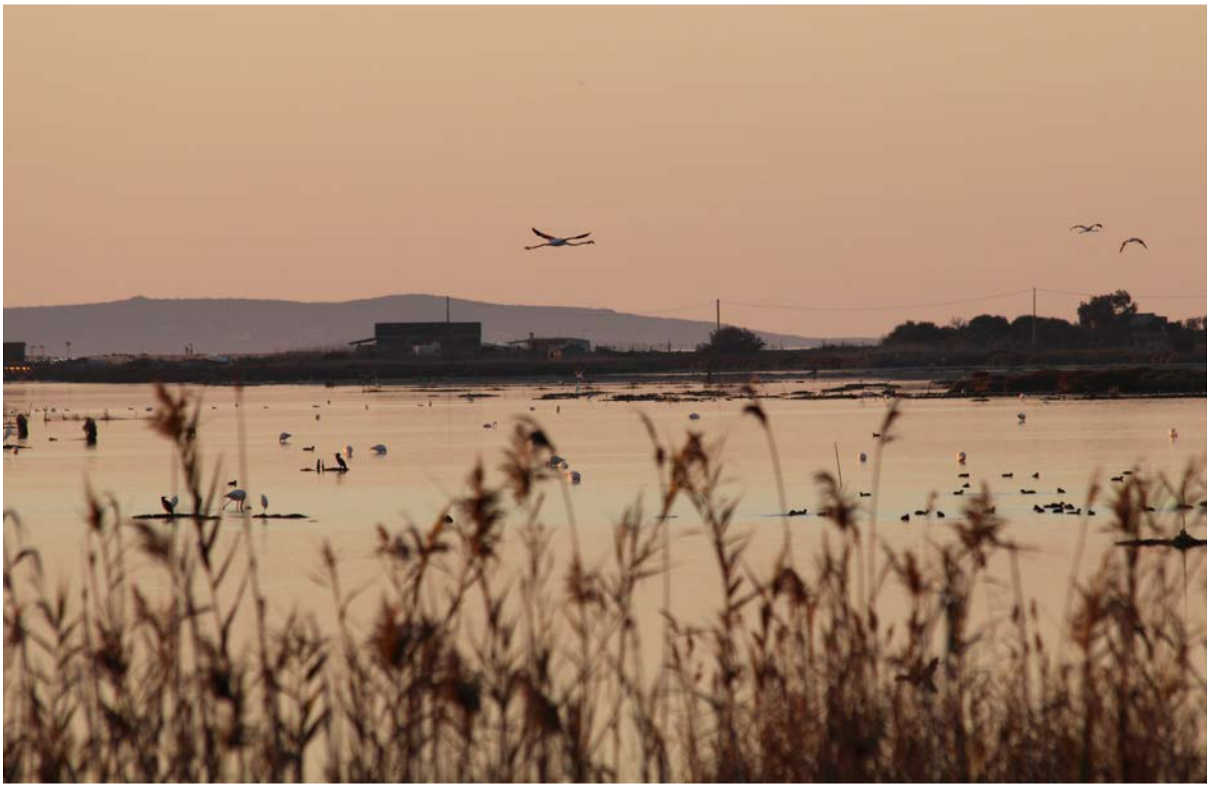

Photo: MEDSEA

Table 1. Analysis based on different valuation approaches

Stakeholder	How this analysis can be used in decision making	An illustrative example from this analysis
Public budget holders Public policy-makers	1. Appreciate the economic value generated by ecosystems in S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni. Compare the dollar value of these ecosystem services with built alternatives. 2. Appreciate the extent to which revenues from local economic development—fisheries, agriculture, and tourism—are dependent on the ecosystem services provided by the wetlands. 3. Make public investment decisions based on the trade-offs that increase the degradation of the Gulf of Oristano ecosystem. 4. Appreciate the value of the infrastructure services provided by the wetland. Estimate the cost of providing the same services with built infrastructure and compare them to the costs of wetland maintenance.	S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni will generate cumulative ecosystem services worth EUR 306 million between 2020 and 2060. If there is no degradation in wetland quality, an additional value of EUR 171 million could be captured over 40 years. If there is no degradation in wetland quality, local governments could receive additional tax revenues of about EUR 338 million for S'Ena Arrubia and EUR 593 million for Corru S'Ittiri-Marceddì-San Giovanni over 40 years. If the wetlands continue to deteriorate, S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni could expect 36% and 48% losses, respectively, in annual average labour income in the aquaculture industry over the next 40 years. The cost of replacing the ecosystem services of S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni with built infrastructure would be EUR 92 million between 2020 and 2060.
Conservation NGOs	1. Make the economic case for continued and heightened wetland restoration. 2. Given the high dollar value of the ecosystem services provided by the wetlands, increase advocacy for its long-term conservation.	S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni will generate cumulative ecosystem services worth EUR 306 million between 2020 and 2060. If there is no degradation in wetland quality, an additional value of EUR 171 million could be captured over 40 years. If the wetlands continue to deteriorate, S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni could expect 36% and 48% losses, respectively, in annual average labour income in the aquaculture industry over the next 40 years. With the right policy response and a sufficient level of spending, a healthy wetland can generate significantly more value by enabling additional ecosystem services and business activity than if it is degrading over time.

Stakeholder	How this analysis can be used in decision making	An illustrative example from this analysis
Public and private investors Public donors Tourism, agriculture, fisheries, aquaculture sectors	1. Appreciate the economic value generated by wetland ecosystems in S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni. Compare the dollar value of these ecosystem services with built alternatives. 2. Use due diligence to make grant and concessional lending decisions. Note that climate change-induced drought, costal erosion, and salinization of aquifers make the wetland ecosystem a very cost-effective service provider. 3. Assess the feasibility of investment opportunities using the scenarios and forecasts of this analysis as a baseline for due diligence—for example, the feasibility for "pay-for-performance" projects, carbon offsets, mitigation banks, and more.	S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni generate substantial economic and societal benefits at an attractive cost when compared to the cost of wetland maintenance or the cost of built infrastructure solutions. In other words, these wetlands are able to deliver value for money while being a worthwhile investment for local businesses, municipalities, and taxpayers. The cost of replacing the ecosystem services of S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni with built infrastructure would be EUR 92 million between 2020 and 2060.

Photo: Vania Statz

Table 2. Analysis on circular business opportunities: Reusing livestock manure

Stakeholder	How this analysis can be used in decision making	An illustrative example from this analysis
Public budget holders Public policy-makers	Assess the value generated by implementing the circular business opportunity to reuse manure for the production of biogas and as fertilizer.	After adjusting for the cost of production facilities, the circular business scenario generates a net benefit of EUR 81.3 million in S'Ena Arrubia and EUR 124.2 million in Corru S'Ittiri-Marceddì-San Giovanni. Through the sale of biogas, compost, and pellets, livestock farmers in S'Ena Arrubia can generate cumulative profits close to EUR 79 million and annual profits of EUR 2 million. In the case of Corru S'Ittiri-Marceddì-San Giovanni, livestock farmers would earn EUR 96.5 million in cumulative profit, with annual profits of EUR 2.4 million.
Conservation NGOs	Assess the avoided costs and added benefits of the reuse of manure.	The avoided social costs of carbon due to carbon sequestration from the wetland and the avoided cost of fertilizers
Public and private investors Agriculture sector	Assess the investment costs, operating costs, avoided costs, and added benefits of the reuse of manure.	The cumulative investment costs to set up the production facilities and logistical arrangements to reuse the manure to produce bioenergy, compost, and pellets are EUR 81.2 million for S'Ena Arrubia and EUR 106.7 million for Corru S'Ittiri-Marceddì-San Giovanni. Significant net revenues can be earned through the circular economy business proposition. These revenues total EUR 160 million in S'Ena Arrubia and EUR 203 million in Corru S'Ittiri-Marceddì-San Giovanni. The improved wetland quality as a result of less nitrogen leakage strongly impacts the aquaculture sector. The resulting increase in labour income reaches EUR 4 million for S'Ena Arrubia and EUR 8.1 million in Corru S'Ittiri-Marceddì-San Giovanni. The value of all ecosystem services increases, with the exception of the value of nitrogen removal. This results in a total value of ecosystem services of EUR 7.9 million for S'Ena Arrubia and EUR 4.8 million for Corru S'Ittiri-Marceddì-San Giovanni over the 20-year period.

Table 3. Analysis on direct payments to farmers for the provision of ecosystem services

Stakeholder	How this analysis can be used in decision making	An illustrative example from this analysis
Public budget holders Public policy-makers	Assess the case for re-targeting direct income support in the agriculture sector toward better environmental performance.	In S'Ena Arrubia, the wetlands provided ecosystem services worth EUR 135/ha/year in 2000. Wetland degradation has slightly decreased the value of ecosystem services to EUR 120/ha/year in 2020. In Corru S'Ittiri-Marceddì-San Giovanni, the wetland provided ecosystem services worth EUR 320/ha/year in 2000. Due to wetland degradation, the value declined by EUR 87, to EUR 234/ha/year in 2020. The average value of EU direct payments to farmers, EUR 266/ha/year, is comparable to the value of the ecosystem services provided by the wetlands. Indeed, farmers in the Province of Arborea (where the S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni wetlands are located) are reported to receive higher payments of EUR 300–800/ha/year. These payments are only marginally linked to the farm's environmental performance.
Conservation NGOs	Make the case for linking agricultural subsidies to environmental performance.	In 2000, the S'Ena Arrubia wetlands provided ecosystem services worth EUR 135/ha/year. By 2020, wetland degradation had slightly decreased the value of ecosystem services to EUR 120/ha/year. In 2000, the Corru S'Ittiri-Marceddì-San Giovanni wetlands provided ecosystem services worth EUR 320/ha/year. By 2020, due to wetland degradation, the value had declined by EUR 87, to EUR 234/ha/year.

2.0 The Context

This assessment uses the Sustainable Asset Valuation (SAVi) tool to calculate the economic and societal value generated by the S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni wetlands in the Gulf of Oristano in Sardinia, Italy.

The study was requested by the MAVA Foundation, the Mediterranean Sea and Coast (MEDSEA) Foundation, local municipalities, and livestock and fisheries entrepreneurs to demonstrate the economic and financial case for the continued maintenance and sustainable use of the wetland in the years ahead.

More specifically, these stakeholders requested that we use SAVi to calculate the following:

- The dollar value of the ecosystem services provided by the wetlands.
- The dollar value of the labour income generated by tourism, fisheries, and agriculture that is enabled and enhanced by the wetland.
- Capital and operating costs of built infrastructure that will provide the same output of services. This is important to enable stakeholders to compare and contrast natural capital with built assets.
- Financial feasibility of circular economy solutions in the reuse of agricultural waste.
- The possibility of re-targeting direct income support in the agriculture sector toward better environmental performance.

The SAVi assessment covers the S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni wetlands located in the Gulf of Oristano in Sardinia, Italy (see Figure 1). They are protected by the Ramsar Convention, an international treaty for the conservation and sustainable use of wetlands.[1] The two sites are important biodiversity reservoirs due to the presence of numerous plant and animal species, and they provide essential ecosystem services. They enable a range of local industries, including agriculture, tourism, fisheries, and aquaculture.

[1] For more about the Convention of Wetlands, see: https://www.ramsar.org/about-the-convention-on-wetlands-0

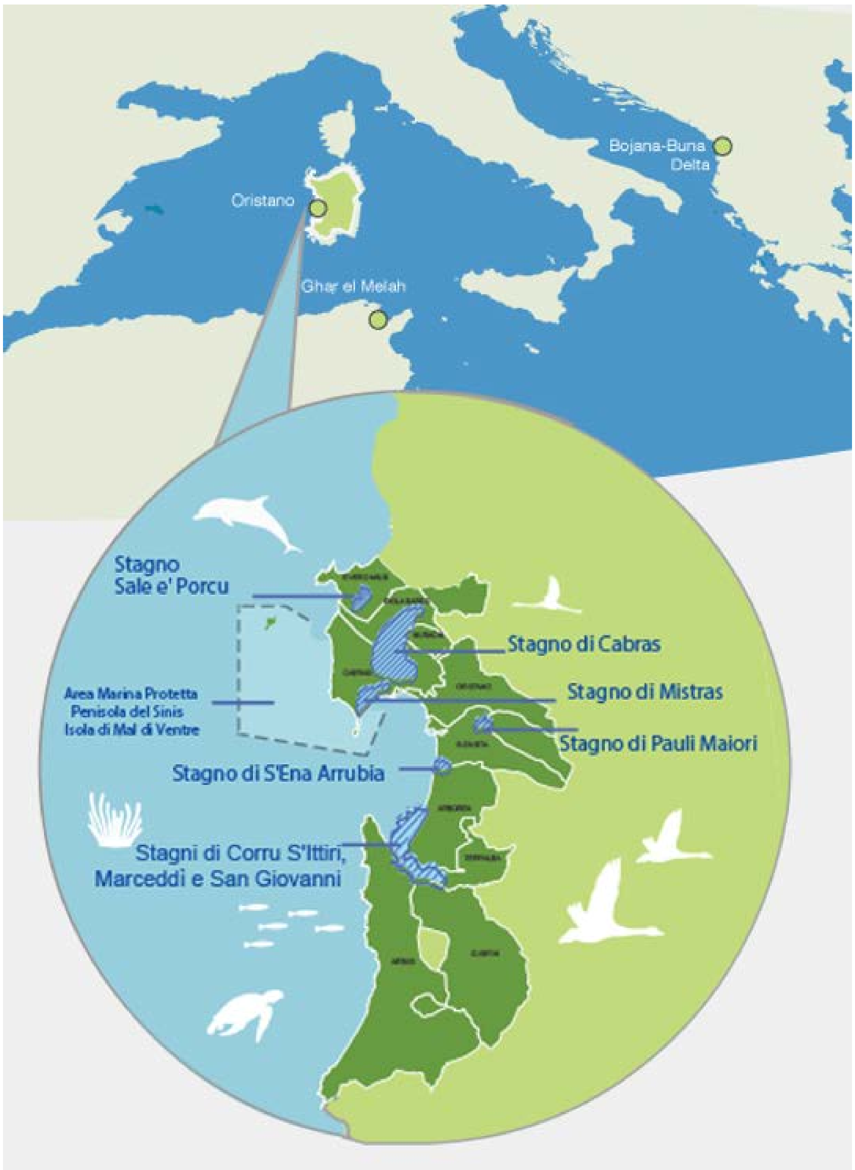

Figure 1. Ramsar-protected wetlands in the Gulf of Oristano

Source: MEDSEA Foundation, n.d.b (reprinted with permission)

S'Ena Arrubia is a 223-ha freshwater lagoon. It is part of the last remaining area of the vast wetland that was converted into agricultural land in the 1930s. The vegetation includes various salt-tolerant plants, submergent species, and emergent reedbeds. The wetland is also home to various species of water birds and provides for their breeding, staging, and wintering (Maristanis, n.d.). The neighbouring municipalities are Arborea, Santa Giusta, and Marrubiu.

Photo: David Uzsoki

Corru S'Ittiri-Marceddì-San Giovanni is a series of interconnected coastal lagoons with a combined size of 2,610 ha. The lagoons have varying levels of salinity, with dunes partly separating them from the sea. Vegetation includes halophytic plants and reedbeds. The lagoons are also rich in fish fauna (Maristanis, n.d.). They are surrounded by the municipalities of Arborea, Terralba, Guspini, and Arbus.

Photo:David Uzsoki

BOX 1. THE MARISTANIS PROJECT OF THE MEDITERRANEAN SEA AND COAST (MEDSEA) FOUNDATION

The Maristanis is an international project that was initiated with the aim of restoring, protecting, and connecting the wetlands of the Gulf of Oristano in an integrated system of governance and sustainable development. It was co-funded by the MAVA Foundation and is coordinated by the MEDSEA Foundation in collaboration with the Marine Protected Area, Sinis Peninsula – Mal di Ventre Island.

The objectives of the project are:

1. Improving knowledge of wetlands
2. Achieving integrated coastal wetlands management
3. Reducing threats to marine ecosystems
4. Promoting efficient water resource management and use
5. Reducing the risk from pollution sources
6. Improving the conservation of endangered species and habitats
7. Enhancing cultural and landscape heritage
8. Raising awareness on the importance of wetlands.

Source: MEDSEA Foundation, n.d.a, n.d.b.

The lagoons in the Gulf of Oristano are exposed to a range of anthropogenic and climate-related threats. The anthropogenic threats include intensive agriculture, livestock, and aquaculture activities; pollution from waste and mining activities; and the abandoning of irrigation and drainage canals. Climate threats stem from the sea level, which increases coastal erosion, saltwater intrusion, loss of biodiversity, and the emergence of alien and invasive species. Moreover, the changing climate is bringing long, prevailing droughts to the region—water supply for the agriculture sector and municipalities is a critical challenge. Local agricultural businesses, working through cooperatives, value the interaction with nature and are therefore looking for solutions to preserve it.

Finally, we would like to acknowledge the complementarity of the *Toolkit for Ecosystem Service Site-based Assessment* (TESSA), developed by BirdLife International, among others, with this assessment. It provides guidance on the valuation of benefits provided by nature (see Box 2). The information collected by TESSA could be especially useful to IISD's SAVi tool, the methodology used for this assessment. TESSA focuses on local data, collecting them mainly through on-field measurements. SAVi applications, which rely on third-party data sources, can leverage this data to generate more fine-tuned, locally relevant results for nature-based solutions.

BOX 2. THE TOOLKIT FOR ECOSYSTEM SERVICE SITE-BASED ASSESSMENT (TESSA)

The toolkit provides accessible guidance on low-cost methods for how to evaluate the benefits people receive from nature at particular sites in order to generate information that can be used to influence decision making. It has the following components:

- An overview of ecosystem services, key concepts, and caveats.
- Guidance on conducting a preliminary scoping appraisal at a site (or multiple sites) to understand the important services provided by a site and to whom.
- Decision trees (flow charts) to lead the user to the most appropriate methods according to the characteristics of the site.
- Methods for measuring the ecosystem services listed above.
- The valuation of an "alternative state" in order to compare a current and alternative state of the site and hence estimate the impact of potential or actual changes on the ecosystem services provided.
- Working examples on how to derive a value (quantitative, including potentially economic and/or qualitative) for each service, including presenting the difference in value between two states of the site.
- Guidance on how to synthesize the data for each service into a summary of ecosystem service change at the site scale.
- Guidance on assessing how benefits are spread across different beneficiary groups.

Source: BirdLife International, 2020.

Photo: Vania Statz

3.0 Design of this Assessment

This assessment involves systems thinking and simulation designed based on:

- Broad, cross-cutting scenarios
- Valuation approaches
- A circular business proposition
- Direct payments to farmers for the provision of ecosystem services.

These elements are summarized in Table 4.

All these elements were designed in close collaboration with the MEDSEA Foundation; local businesses working on aquaculture, tourism, and agriculture; and policy-makers from municipal governments. The simulation is also based on extensive primary and secondary research and draws, to the greatest extent possible, from site-specific data. We collaborated very closely with the MEDSEA Foundation and local entrepreneurs to collect, screen, and verify data. But despite our collective best efforts, data gaps do prevail. We therefore worked further with all stakeholders to develop assumptions and proxies to fill the data gaps but still reflect the realities of the local context.

Table 4. Design overview of the SAVi assessment of the wetlands of S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni

Overarching cross-cutting scenarios that are used across Sections 1 and 2 of the results	Components/description
Prevailing threats continue to degrade the ecological characteristics and ecosystem services provided by the wetlands. No conservation activities are undertaken. We call this the "continued degradation" scenario.	Prevailing and historical trends and threats continue to degrade the wetlands. The SAVi Wetland Quality Index was customized with indicators on: • Soil erosion • Nitrogen concentration • Vegetation cover.
Conservation activities are conducted to improve the integrity of the wetlands. We call this the "no damages" scenario.	A hypothetical scenario, under which continued maintenance is undertaken and the wetland quality does not degrade.
Section 1 Valuation approaches	
Value of ecosystem services.	• Value of nitrogen removal • Value of avoided social cost of carbon • Value of flood control • Value of water filtration • Value of water supply • Value of amenity and recreation • Value of habitat nursery • Value of biodiversity • Value of materials

Overarching cross-cutting scenarios that are used across Sections 1 and 2 of the results	Components/description
Compare the capital and operating costs of the wetland with built alternatives that would deliver the same volume of service. This helps stakeholders appreciate the extent to which the wetlands can provide infrastructure services in a cost-efficient manner compared to built infrastructure solutions.	• N removal • P removal • Carbon mitigation services
Labour income generated by industries that directly benefit from the ecological characteristics of the wetland.	• Tourism • Aquaculture and fisheries • Agriculture – livestock and crops
Section 2 Circular business opportunity	
Reusing livestock manure as fertilizer for crops.	Reprocessing and retailing manure: • To produce biogas • As compost • As pellets
Section 3 Direct payments to farmers for the provision of ecosystem services	
Exploring the possibility of re-targeting direct income support in the agriculture sector toward better environmental performance.	• Value of ecosystem services delivered (euros/ha/year in 2020) • Direct payments received by farmers located in the Province of Arborea (euros/ha/year)

Photo: Vania Statz

4.0 Assumptions

While we collaborated very closely with the MEDSEA Foundation and local stakeholders to collect and verify data specific to the S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni wetlands, we experienced substantial gaps. Indeed, data gaps prevailed across all sections of this analysis: the valuations approaches, the scenarios, and the circular business approaches.

We therefore developed a range of assumptions to fill in these data gaps. These assumptions are based on extensive research and expert consultations. They were shared with and signed off by the local stakeholders.

4.1 Assumptions Used to Design the Broad, Cross-Cutting Scenarios

The assessment includes two scenarios with different levels of wetland degradation: a "continuing degradation" scenario and a "no degradation" scenario. Under the former, we assume that the degradation will continue in the future. To demonstrate the value lost due to degradation, we developed the "no degradation" scenario. In this case, we assume that all the necessary steps have been taken to stop the wetland degradation trend. This is a hypothetical scenario and is not based on any specific policy intervention.

Table 5. Assumptions for wetland degradation scenarios

Wetland degradation scenarios	Assumptions
Prevailing threats continue to degrade the wetlands	This scenario assumes that historical trends and environmental threats persist, prompting the continued degradation of the wetlands. As a result, the benefits provided by the wetland, as measured across all the valuation approaches, will decrease accordingly. The wetland degradation is measured by the Wetland Quality Index, whose indicators are soil erosion, nitrogen concentration, and vegetation cover.
No degradation	No degradation takes place as a result of the necessary policies put in place. There is also enough financing available for the maintenance of the sites. This is a hypothetical scenario.

4.2 Assumptions About the Valuation Approaches

4.2.1 Assumptions About Ecosystem Services

Table 6. Assumptions about the valuation of ecosystem services

Ecosystem service component	Assumptions
Value of nitrogen (N) removal	This valuation considers the avoided environmental damage from the uptake of N rather than disposing of it in the open sea. EUR 4.60 per kg N is assumed, based on UNEP (2015).
Value of amenity and recreation **Value of biodiversity** **Value of flood control** **Value of habitat nursery** **Value of materials** **Value of water filtration** **Value of water supply**	These values are based on multipliers obtained from the WWF study, *The Economic Values of the World's Wetlands* (Schuyt & Brander, 2004). In our assessment, this multiplier can increase or decrease in line with changes in wetland quality. **The multipliers used are:** • Amenity and recreation: USD 492/ha/year • Biodiversity: USD 214/ha/year • Flood control: USD 464/ha/year • Habitat nursery: USD 201/ha/year • Materials: USD 45/ha/year • Water filtration: USD 288/ha/year • Water supply: USD 45/ha/year
Value of avoided social cost of carbon	**Baseline assumptions:** Social cost of carbon (SCC): USD 31/tonne of carbon dioxide equivalent (tCO_2e) CO_2e absorption from wetland: 3.25 tCO_2e/ha The SCC represents the economic cost of an additional tonne of carbon dioxide or its equivalent. The avoided SCC from the wetland is calculated based on the SCC of 31 USD/tCO_2e provided by Nordhaus (2017). Carbon sequestration from wetlands is calculated based on the total wetland area, the absorption per hectare, and the wetland quality.

4.2.2 Assumptions About Labour Income

Table 7. Assumptions about the labour income generated by the wetland

Sectors	Assumptions
Cross-sector assumption on income tax	17% per annum
Labour income from aquaculture and fisheries	**S'Ena Arrubia** Number of people employed in aquaculture: 30/year Average salary per person: EUR 14,303/person/year The labour income from aquaculture is based on the assumption that the cooperative is run by 20 families, and that 1.5 persons per family are employed. Labour income is assumed at EUR 14,300 per person per year but depends on the yield, which is affected by wetland quality. Baseline aquaculture production is calibrated based on information provided by the Cooperativa Pescatori Sant'andrea Marrubiu (Madeddu, 2004). **Corru S'Ittiri-Marceddì-San Giovanni** Number of people employed in aquaculture: 225 per year Average salary per person: EUR 14,303 per person per year The labour income from aquaculture is based on the assumption that the cooperative employs 225 people, including 210 full-time and 50 additional workers during peak season. Labour income is assumed at EUR 14,300 per person per year but depends on the yield, which is affected by wetland quality. Baseline aquaculture production is calibrated based on information obtained from various sources. Labour income from fisheries is captured in the labour income from aquaculture, as Niedditas, the main local producer that the data is based on, is active in both areas. Information on the relative shares of production was not available.
Labour income from tourism	**S'Ena Arrubia** Number of people visiting (2018): 29,500 tourists/year* Average length of stay: 4.42 days/person* Average employment per tourist: 0.05945 persons/tourist/year Average spending per day: EUR 100/tourist/day **Corru S'Ittiri-Marceddì-San Giovanni** Number of people visiting (2018): 57,600 tourists/year* Average length of stay: 3.55 days/person* Average employment per tourist: 0.05945 persons/tourist/year Average spending per day: EUR 100/tourist/day Based on local data, 54.8% of tourists visit the lagoon. Only 26% of those tourists stay overnight; the rest stay only for the day. We assumed that the remaining 15.92% of tourists that visit the lagoon come visit the area because of the lagoon.

Sectors	Assumptions
Labour income from agriculture	**Baseline assumptions:** Average employment per hectare: 0.1654 person Average salary per person: EUR 17,164/person/year Employment from agriculture, including livestock, is estimated based on the number of hectares used for agricultural land. With the data available, it was not possible to distinguish between employment from livestock and from crop production.

**Data marked with an asterisk is derived from Sardegna Turismo, n.d.; uncited data is based on author assumptions.*

4.2.3 Assumptions Used When Comparing the Capital and Operating Costs of the Wetland With Built Alternatives That Would Deliver the Same Volume of Service

Table 8. Assumptions about the cost of built infrastructure that can provide services with the same level of output as the wetland

Components	Assumptions
N and P removal	**N removal:** Cost per kg of N removed: EUR 52.15/kg N removed **P removal:** Cost per kg of P removed: EUR 62.16/kg P removed These are the costs of establishing a wastewater treatment capacity that removes the same amount of N/P from canal effluent as the wetland. The value is based on an average value calculated based on TetraTech (2011) for various technologies.
Carbon mitigation	**Baseline assumptions:** Carbon sequestration from wetland: 3.25 tCO_2e/ha/year Emissions per MWh of coal energy: 0.87 tonnes/MWh Load factor solar: 20% Capital cost solar: USD 1,800,000/MW Operating and management (O&M) cost for solar: 2% of capital expenditure (capex) The assessment used power generation as a comparator to estimate the costs of built infrastructure required to decrease carbon dioxide emissions with the same amount as the wetland. Most of the energy used in the area is from coal. Therefore, we used solar, a zero-emission alternative to coal, to estimate the cost of achieving the same level of carbon emission decrease that is currently being captured by the wetland.

4.2.4 Assumptions Used to Calculate Wetland Maintenance Costs

Insight into annual maintenance costs of the wetland helps stakeholders better appreciate the value of the benefits it delivers. As site-specific maintenance data are not available, we used an aggregate amount that includes both the S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni wetland sites.

Table 9. Aggregated maintenance costs of the S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni wetland sites

Costs	Assumptions
Operational expenditure (opex)	**Baseline assumption: EUR 609,067/year** The annual opex was calculated based on the cost of the annual maintenance items, as cited in the 2019 budget of the reclamation area (Consorzio Di Bonifica dell'Oristanese, 2019). These costs are: • Electricity – wetland remediation infrastructure • Purchases of services and rental costs for wetland remediation • Expenditure on materials and supplies for wetland remediation • Purchases of services for works on wetland remediation • Expenditure on materials and supplies for work on wetland remediation infrastructure • Expenses for maintenance activities of wetland remediation infrastructure. The size of the two wetland sites assessed comprises 63% of the total reclamation area. The opex was adjusted to reflect this.
Capital expenditure (capex)	**Baseline assumption: EUR 271,865/year** The annual capex was calculated based on the cost of the large-scale capex items in the 2019 budget of the reclamation area. These costs were: • Realization of settling tanks • Investment in support fishing • Hydrogeological risk mitigation measures • Investments to guarantee regular water flow and quality. The two wetland sites under assessment comprise 63% of the total reclamation area. The capex was adjusted to reflect this. The capex values were annualized based on the assumption of a 20-year lifetime. We also assumed that 5% of the annual capex would be allocated for maintenance.

4.2.5 Assumptions on the Circular Business Approaches

There is unrealized value generation potential in using manure as organic fertilizer. It is currently being discarded, which not only increases the nitrogen loading of the wetlands but also deprives farmers of an additional source of revenue. Furthermore, local agricultural production still relies on chemical fertilizers, which further degrade wetland quality due to higher nitrogen leakage compared to manure.

We assessed the value creation potential of manure by focusing on the three main ways it can be utilized in the agricultural sector, namely the production of biogas, compost, and pellets.

Table 10. Assumptions on circular business approaches in using livestock manure as fertilizer

Components	Assumptions
Cross-component assumptions	• 50% of the manure available will be collected and transformed into biogas, compost, or pellets. • Construction time of 3 years for the necessary production facilities. • Manure would replace 50% of the chemical fertilizers used currently.
Compost production	**S'Ena Arrubia** Share of manure composted: 20% **Corru S'Ittiri-Marceddì-San Giovanni** Share of manure composted: 35% **Both sites** Share of dry mass in compost: 47% Price (local): EUR 10/tonne Average production cost: EUR 39/tonne Price (export): EUR 120/tonne Cost of fertilizer: EUR 364/tonne According to Consorzio Italiano Compostatori (2017), the price of quality compost can be between EUR 5 and 15 per tonne. The difference in prices is probably due to changes in the transportation cost, which is often paid by the composting plants. A significant part of the production cost is the cost of separation (EUR 32/tonne). We assumed that any manure that is not sold locally is exported.

Components	Assumptions
Pellet production	**S'Ena Arrubia** Share of manure converted to pellets: 50% **Corru S'Ittiri-Marceddì-San Giovanni** Share of manure converted to pellets: 40% **Both sites** Share of dry mass pellets: 87% Price: EUR 234/tonne Average production cost: EUR 89/tonne We assumed that all pellets produced would be exported. Pellet prices can vary based on the packaged amount, content, and the season. The price of pellets for heating is typically between EUR 228 and 240 per tonne in the European Union (EU). The price of imported pellets can be considerably lower.
Bioenergy production	**S'Ena Arrubia** Share of manure used for bioenergy: 30% **Corru S'Ittiri-Marceddì-San Giovanni** Share of manure used for bioenergy: 25% **Both sites** Energy content of poultry and pig manure: 0.45357 MWh/tonne Energy content of residual manure: 0.09304 MWh/tonne Price of electricity from biogas: EUR 140/MWh Average production cost: EUR 132/MWh The proportion of manure used for bioenergy production was determined on the basis that it needs to cover the energy needs of pellet production while generating some excess energy that can be sold. We assumed that biogas production yields a positive return of EUR 8/MWh produced.

5.0 The Results

The section presents the results of the SAVi assessment across the scenarios, valuation approaches, circular business opportunities, and the direct payments to farmers for the provision of ecosystem services. These are recapitulated in Table 11.

Table 11. Design overview of the SAVi on the wetlands of S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni

Overarching cross-cutting scenarios that are used across Sections 1 and 2 of the results	Components/description
Prevailing threats continue to degrade the ecological characteristics and ecosystem services provided by the wetlands. No conservation activities are undertaken. We call this the "continued degradation" scenario.	Prevailing and historical trends and threats continue to degrade the wetlands. The SAVi Wetland Quality Index was customized with indicators on: • Soil erosion • Nitrogen concentration • Vegetation cover
Conservation activities are conducted to improve the integrity of the wetlands. We call this the "no damages" scenario.	A hypothetical scenario, under which continued maintenance is undertaken, and the wetland quality does not degrade.
Section 1 Valuation approaches	
Value of ecosystem services.	• Value of nitrogen removal • Value of avoided social cost of carbon • Value of flood control • Value of water filtration • Value of water supply • Value of amenity and recreation • Value of habitat nursery • Value of biodiversity • Value of materials
Compare the capital and operating costs of the wetland with built alternatives that would deliver the same volume of service. This helps stakeholders appreciate the extent to which the wetlands can provide infrastructure services in a cost-efficient manner compared to built infrastructure solutions.	• N removal • P removal • Carbon mitigation services
Labour income generated by industries that directly benefit from the ecological characteristics of the wetland.	• Tourism • Aquaculture and fisheries • Agriculture – livestock and crops

Overarching cross-cutting scenarios that are used across Sections 1 and 2 of the results	Components/description
Section 2 Circular business opportunity	
Reusing livestock manure as fertilizer for crops.	Reprocessing and retailing manure: • To produce biogas • As compost • As pellets
Section 3 Direct payments to farmers for the provision of ecosystem services	
Exploring the possibility of re-targeting direct income support in the agriculture sector toward better environmental performance.	• Value of ecosystem services delivered (euros/ha/year in 2020) • Direct payments received by farmers located in the Province of Arborea (euros/ha/year)

5.1 Results of the Valuation Approaches

5.1.1 Aggregated Performance on Wetland Quality

The charts below are developed using the SAVi Wetland Quality Index, specially created to depict the impact of a range of indicators on the the value creation capacity of wetlands. In this case, the index was customized with indicators on soil erosion, nitrogen concentration, and vegetation cover.

In the case of S'Ena Arrubia, we observe that wetland quality decreases by about 60% over the 60-year period. This is the result of nitrogen concentration and soil erosion in the area. We observe a similar trend in Corru S'Ittiri-Marceddì-San Giovanni, where, after a brief improvement due to a decrease in population, the wetland continuously deteriorates, dropping by 80% compared to the "no degradation" scenario by 2060. The causes are linked again to nitrogen concentration and soil erosion in the area.

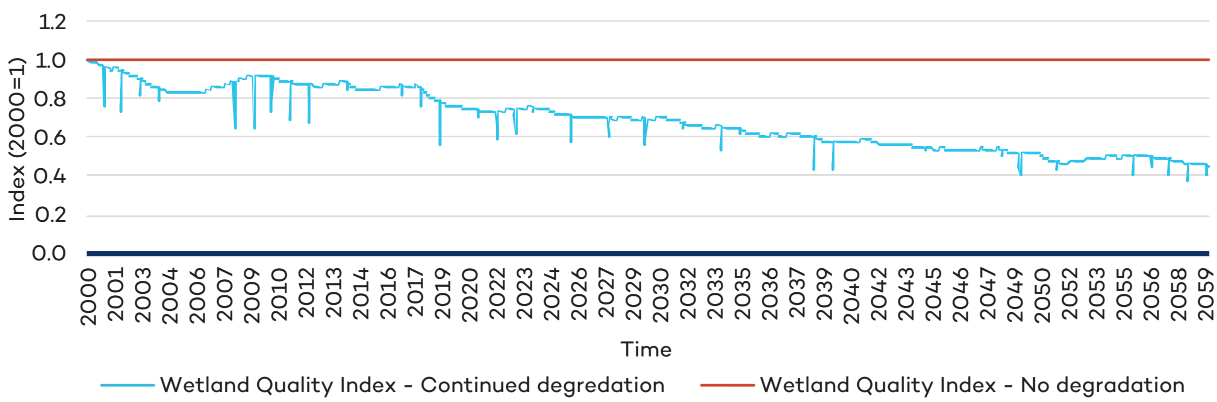

Figure 2. Wetland Quality Index for S'Ena Arrubia, 2000 to 2060

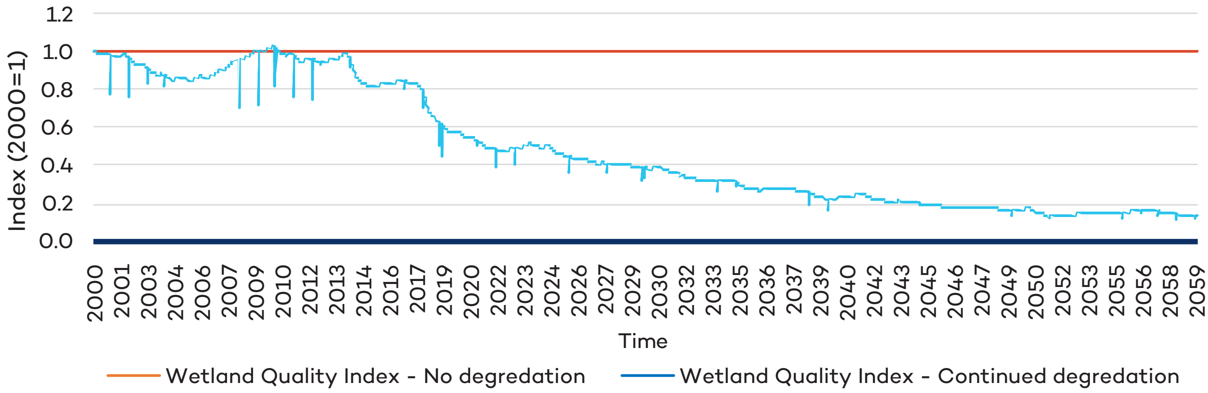

Figure 3. **Wetland Quality Index for Corru S'Ittiri-Marceddì-San Giovanni, 2000 to 2060**

5.1.2 Disaggregated Values of Ecosystem Services

The following tables show the disaggregated valuations of ecosystem services for S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni under the "continued degradation" and "no degradation" scenarios.

Both tables reflect a decrease in the value of ecosystem services, the removal of nitrogen being, by far, the highest loss. Nitrogen removal is a particularly important ecosystem service given that the wetlands are home to both livestock and crop agriculture and aquaculture. While nitrogen fertilizer is essential to healthy crops, issues are arising due to patterns in the application of fertilizer and subsequent runoff. In addition, nitrogen runoff occurs from livestock waste being left on land the degrade. All efforts to reduce the excessive use of nitrogen is therefore critically important to maintain the wetland.

Sharing these results with local stakeholders gave rise to the simulation on the circular business opportunity, in which we simulated the revenues and ecosystem gains from reusing livestock manure for biogas production and the processing of compost and pellets.

Table 12. Continued degradation scenario: Disaggregated value of ecosystem services, 2020–2060, S'Ena Arrubia

Ecosystem services	Currency	5 years	10 years	20 years	40 years	Annual average
Value of N removal	Euro	7,792,768	15,973,768	32,942,856	69,051,880	1,726,297
Value of amenity and recreation	Euro	503,176	980,116	1,844,936	3,254,621	81,366
Value of biodiversity	Euro	218,860	426,309	802,468	1,415,628	35,391
Value of flood control	Euro	660,675	1,286,899	2,422,411	4,273,342	106,834
Value of habitat nursery	Euro	205,567	400,413	753,724	1,329,632	33,241
Value of materials	Euro	46,022	89,645	168,744	297,679	7,442
Value of water filtration	Euro	294,542	573,726	1,079,961	1,905,145	47,629
Value of water supply	Euro	46,022	89,645	168,744	297,679	7,442
Avoided SCC from wetland	Euro	103,040	200,705	377,799	666,470	16,662
Total – Ecosystem services	**Euro**	**9,870,672**	**20,021,226**	**40,561,643**	**82,492,074**	**2,062,302**

Table 13. Continued degradation scenario: Disaggregated value of ecosystem services, 2020–2060, Corru S'Ittiri-Marceddì-San Giovanni

Ecosystem services	Currency	5 years	10 years	20 years	40 years	Annual average
Value of N removal	Euro	18,205,480	37,915,280	79,250,424	168,216,008	4,205,400
Value of amenity and recreation	Euro	2,995,652	5,494,952	9,130,562	13,329,408	333,235
Value of biodiversity	Euro	1,302,990	2,390,088	3,971,420	5,797,766	144,944
Value of flood control	Euro	3,933,334	7,214,896	11,988,496	17,501,640	437,541
Value of habitat nursery	Euro	1,223,837	2,244,891	3,730,173	5,445,567	136,139
Value of materials	Euro	273,994	502,587	835,113	1,219,154	30,479
Value of water filtration	Euro	1,753,553	3,216,551	5,344,715	7,802,603	195,065
Value of water supply	Euro	273,994	502,587	835,113	1,219,154	30,479
Avoided SCC from wetland	Euro	613,440	1,125,235	1,869,717	2,729,544	68,239
Total – Ecosystem services	**Euro**	**30,576,274**	**60,607,067**	**116,955,733**	**223,260,843**	**5,581,521**

Table 14. No degradation scenario: Disaggregated value of ecosystem services, 2020–2060, S'Ena Arrubia

Ecosystem services	Currency	5 years	10 years	20 years	40 years	Annual average
Value of N removal	Euro	7,965,906	16,356,514	33,900,046	71,734,426	1,793,361
Value of amenity and recreation	Euro	679,600	1,359,200	2,718,546	5,437,266	135,932
Value of biodiversity	Euro	295,600	591,200	1,182,400	2,364,800	59,120
Value of flood control	Euro	892,376	1,784,696	3,569,336	7,139,032	178,476
Value of habitat nursery	Euro	277,640	555,280	1,110,578	2,221,298	55,532
Value of materials	Euro	62,160	124,320	248,640	497,280	12,432
Value of water filtration	Euro	397,840	397,840	795,680	1,591,243	39,781
Value of water supply	Euro	62,160	124,320	248,640	497,280	12,432
Avoided SCC from wetland	Euro	139,180	278,360	556,711	1,113,351	27,834
Total – Ecosystem services	**Euro**	**10,772,462**	**21,571,730**	**44,330,577**	**92,595,976**	**2,314,899**

Table 15. **No degradation scenario: Disaggregated value of ecosystem services, 2020–2060, Corru S'Ittiri-Marceddì-San Giovanni**

Ecosystem services	Currency	5 years	10 years	20 years	40 years	Annual average
Value of N removal	Euro	19,847,268	41,314,812	87,147,276	187,831,164	4,695,779
Value of amenity and recreation	Euro	5,952,000	11,904,000	23,808,000	47,616,000	1,190,400
Value of biodiversity	Euro	2,589,120	5,178,240	10,355,993	20,711,193	517,780
Value of flood control	Euro	7,815,680	15,631,360	31,262,720	62,525,436	1,563,136
Value of habitat nursery	Euro	2,431,680	4,863,360	9,727,073	19,455,073	486,377
Value of materials	Euro	544,400	1,088,800	2,177,624	4,355,544	108,889
Value of water filtration	Euro	3,484,161	6,968,321	13,936,641	27,873,281	696,832
Value of water supply	Euro	544,400	1,088,800	2,177,624	4,355,544	108,889
Avoided SCC from wetland	Euro	1,218,880	2,437,760	4,875,521	9,751,041	243,776
Total – Ecosystem services	**Euro**	**44,427,589**	**90,475,453**	**185,468,471**	**384,474,275**	**9,611,857**

5.1.3 Results on the Valuation of Labour

As with the valuation of ecosystem services, the valuation of labour income is conducted under the "continued degradation" and "no degradation" scenarios. This calculation assumes an average income tax rate of 17%.

Labour income refers to the share of national income that is derived from wages. Understanding its value in the case of these wetland-dependant sectors is important, as it strengthens the case for continued wetland maintenance.

The results across the two scenarios also show how important the wetlands are for the local economy. If there is no degradation, the wetlands can support more economic activity, resulting in more employment and labour income. The local government could also receive additional tax revenue of about EUR 338 million for S'Ena Arrubia and EUR 593 million for Corru S'Ittiri-Marceddì-San Giovanni over 40 years.

If, on the other hand, the wetlands continue to deteriorate, S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni could expect 36% and 48% losses, respectively, in annual average labour income in the aquaculture industry over the next 40 years.

Table 16. Continued degradation scenario: Labour income generated by S'Ena Arrubia, 2020–2060

Sources of labour income	Currency	5 years	10 years	20 years	40 years	Annual average
Labour income from aquaculture	Euro	1,502,382	2,926,416	5,508,583	9,717,627	242,941
Labour income from tourism	Euro	27,652,114	57,457,697	124,212,876	291,877,443	7,296,936
Labour income from agriculture	Euro	218,809,472	435,172,480	860,837,376	1,684,641,536	42,116,038
Total – Labour income generated	**Euro**	**247,963,968**	**495,556,593**	**990,558,834**	**1,986,236,606**	49,655,915

Table 17. Continued degradation scenario: Labour income generated by Corru S'Ittiri-Marceddì-San Giovanni, 2020–2060

Sources of labour income	Currency	5 years	10 years	20 years	40 years	Annual average
Labour income from aquaculture	Euro	11,412,176	21,834,632	39,570,664	66,494,496	1,662,362
Labour income from tourism	Euro	50,081,793	104,064,146	224,966,852	528,629,770	13,215,744
Labour income from agriculture	Euro	375,602,944	747,025,024	1,477,749,632	2,891,944,832	72,298,621
Total – Labour income generated	**Euro**	**437,096,913**	**872,923,802**	**1,742,287,148**	**3,487,069,098**	87,176,727

Table 18. No degradation scenario: Labour income generated by S'Ena Arrubia, 2020–2060

Sources of labour income	Currency	5 years	10 years	20 years	40 years	Annual average
Labour income from aquaculture	Euro	1,903,520	3,807,184	7,614,544	15,228,467	380,712
Labour income from tourism	Euro	27,652,114	57,457,697	124,212,876	291,877,443	7,296,936
Labour income from agriculture	Euro	218,809,472	435,172,480	860,837,376	1,684,641,536	42,116,038
Total – Labour income generated	**Euro**	**248,365,106**	**496,437,361**	**992,664,796**	**1,991,747,446**	49,793,686

Table 19. No degradation scenario: Labour income generated by Corru S'Ittiri-Marceddì-San Giovanni, 2020–2060

Sources of labour income	Currency	5 years	10 years	20 years	40 years	Annual average
Labour income from aquaculture	Euro	16,091,940	32,184,100	64,368,420	128,737,052	3,218,426
Labor income from tourism	Euro	50,081,793	104,064,146	224,966,852	528,629,770	13,215,744
Labour income from agriculture	Euro	375,602,944	747,025,024	1,477,749,632	2,891,944,832	72,298,621
Total – Labour income generated	**Euro**	**441,776,677**	**883,273,270**	**1,767,084,904**	**3,549,311,654**	88,732,791

5.1.4 Compare the Capital and Operating Costs of the Wetland with Built Alternatives That Would Deliver the Same Volume of Service.

The S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni wetlands provide a range of ecosystem services that fulfill an infrastructure function, which otherwise would be provided by built infrastructure. These services include nitrogen and phosphorus removal and carbon mitigation services. An important way to demonstrate the value of these wetlands is to estimate what the costs of built infrastructure solutions would be to provide the same level of service.

Under the "continued degradation" scenario, significant capital and operating expenditures would be needed to replace the ecosystem services with built infrastructure. There is no significant change in expenditure across time. This is because we assume that the built infrastructure replaces all three ecosystem services at their 2020 levels. Even as the provision of ecosystem services declines due to wetland degradation, there will be no requirement to expand built infrastructure. The relatively small increase in costs over time reflects the annual operating costs of the built alternatives.

Under the "no degradation" scenario, the ecosystem services stay at the same level during the 40 years. This means that the built infrastructure replacing them would need to have a higher output compared to the "continued degradation" scenario. This results in a cost increase of EUR 1.4 million for S'Ena Arrubia and EUR 18.9 million for Corru S'Ittiri-Marceddì-San Giovanni.

Table 20. Continued degradation scenario: Cost of replacement with built infrastructure, S'Ena Arrubia, 2020–2060

Cost of providing service with built infrastructure	Currency	5 years	10 years	20 years	40 years	Annual average
N removal	Euro	18,450,436	19,711,818	20,752,380	21,994,410	549,860
P removal	Euro	1,046,863	1,124,637	1,211,557	1,351,041	33,776
Carbon mitigation	Euro	220,029	463,261	1,012,707	2,291,755	57,294
Total – Replacement costs	**Euro**	**19,717,328**	**21,299,715**	**22,976,644**	**25,637,206**	640,930

Table 21. Continued degradation scenario: Cost of replacement with built infrastructure, Corru S'Ittiri-Marceddì-San Giovanni, 2020–2060

Cost of providing service with built infrastructure	Currency	5 years	10 years	20 years	40 years	Annual average
N removal	Euro	43,850,696	46,184,932	47,809,780	54,180,892	1,354,522
P removal	Euro	2,505,079	2,633,764	2,682,302	2,896,599	72,415
Carbon mitigation	Euro	1,312,367	2,601,455	5,020,268	9,402,537	235,063
Total – Replacement costs	**Euro**	**47,668,141**	**51,420,151**	**55,512,350**	**66,480,027**	1,662,001

Table 22. No degradation scenario: Cost of replacement with built infrastructure, S'Ena Arrubia, 2020–2060

Cost of providing service with built infrastructure	Currency	5 years	10 years	20 years	40 years	Annual average
N removal	Euro	18,897,664	20,270,870	21,780,056	23,320,980	583,025
P removal	Euro	1,106,733	1,196,874	1,337,621	1,548,387	38,710
Carbon mitigation	Euro	275,454	545,841	1,086,603	2,168,131	54,203
Total – Replacement costs	**Euro**	**20,279,851**	**22,013,585**	**24,204,281**	**27,037,498**	675,937

Table 23. No degradation scenario: Cost of replacement with built infrastructure, Corru S'Ittiri-Marceddì-San Giovanni, 2020–2060

Cost of providing service with built infrastructure	Currency	5 years	10 years	20 years	40 years	Annual average
N removal	Euro	47,240,928	50,292,404	54,762,388	62,233,440	1,555,836
P removal	Euro	2,865,861	3,125,411	3,524,558	4,131,284	103,282
Carbon mitigation	Euro	2,412,455	4,780,495	9,516,505	18,988,530	474,713
Total – Replacement costs	**Euro**	**52,519,244**	**58,198,310**	**67,803,451**	**85,353,254**	2,133,831

5.1.5 Cost of Wetland Maintenance

The capital costs refer to the large capex needed for wetland maintenance, while the O&M costs cover regular annual expenses to maintain the sites. The capex of large projects is spread across their expected lifetime of 20 years.

Table 24. Maintenance cost for both S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni, 2020–2060

Costs	Currency	5 years	10 years	20 years	40 years	Annual average
Capital costs	Euro	1,359,321	2,718,663	5,303,566	5,303,566	132,589
O&M costs	Euro	3,045,440	6,090,722	12,180,962	24,361,444	609,036
Total – Maintenance cost	**Euro**	**4,404,761**	**8,809,385**	**17,484,528**	**29,665,010**	741,625

Table 24 shows that the annual maintenance cost for both sites is around EUR 740,000, while the cumulative costs during the 40-year period are close to EUR 29.1 million. These numbers are based on the current level of spending.

Figures 4 to 9 in the following section put these maintenance costs into perspective by comparing them with the value generation by the wetlands.

5.1.6 Summary of Valuation Approaches

This section summarizes the findings from the three valuation approaches and compares them to the cost of maintenance for the wetland sites. It provides a more holistic perspective on the total net contribution of the wetland.

The main takeaway is that S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni generate substantial economic and societal benefits at an attractive cost when compared to the cost of wetland maintenance or the cost of built infrastructure solutions. In other words, these wetlands are able to deliver value for money while being a worthwhile investment for local businesses, municipalities, and taxpayers.

The results also highlight that the labour income attributable to the wetlands generate by far the most value based on our assessment. This is due to the strong reliance of the agriculture and aquaculture sectors on the ecosystem services the wetlands provide. Businesses in the aquaculture sector can even include a price premium due to the increased quality and unique characteristics of their products.

As demonstrated in Figures 8 and 9, a continuously degrading wetland is a lost opportunity for local municipalities, businesses, and taxpayers. With the right policy response and a sufficient level of spending, a healthy wetland can generate significantly more value by enabling additional ecosystem services and business activity than if it is degrading over time. While determining the right intervention options is beyond the scope of this assessment, our results can help decision-makers to understand the value generation potential of wetlands and inform budget allocation decisions accordingly.

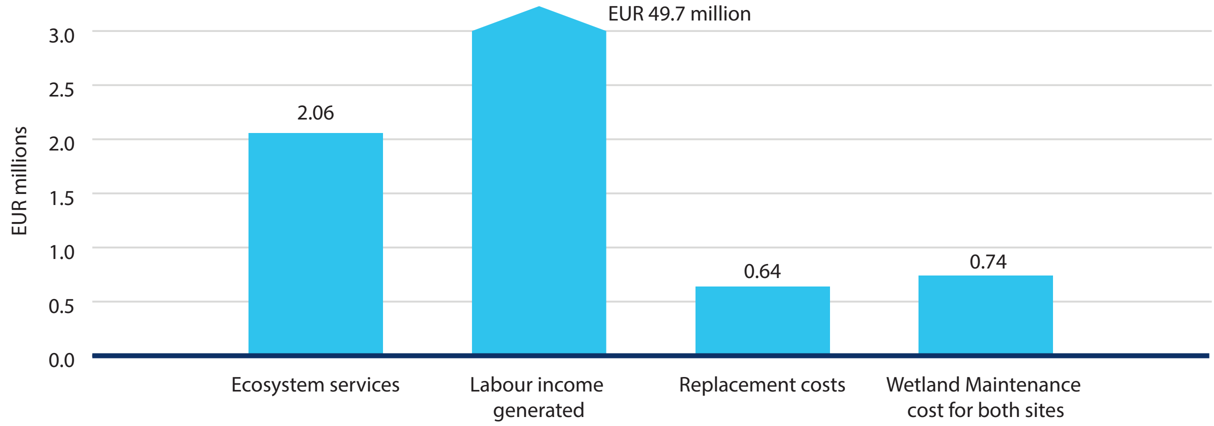

Figure 4. S'Ena Arrubia – Annual average valuation with maintenance costs, continued degradation scenario

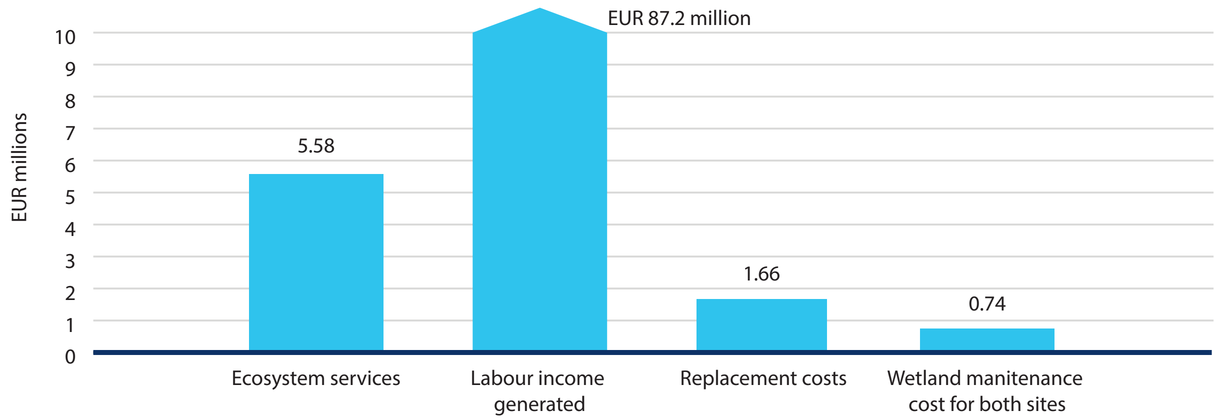

Figure 5. Corru S'Ittiri-Marceddì-San Giovanni – Annual average valuation with maintenance costs, continued degradation scenario

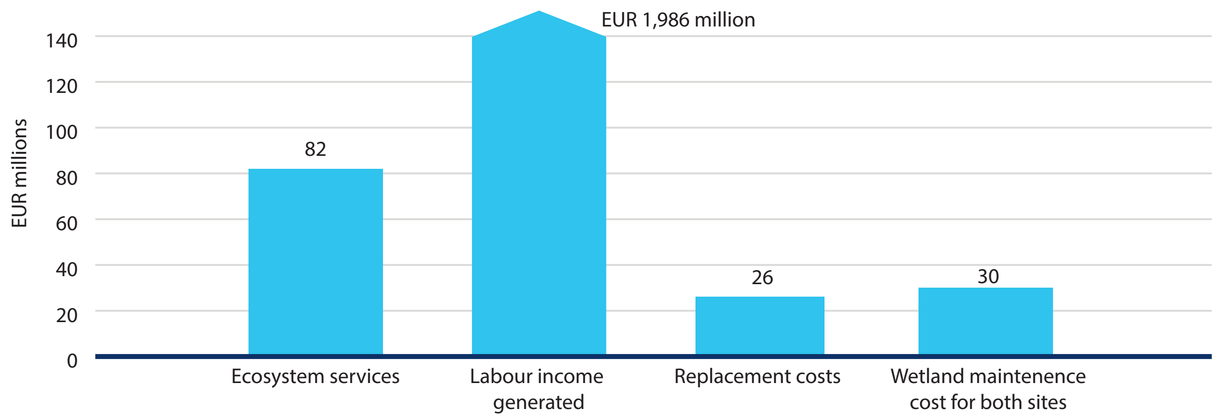

Figure 6. S'Ena Arrubia – Cumulative values over 40 years, continued degradation scenario

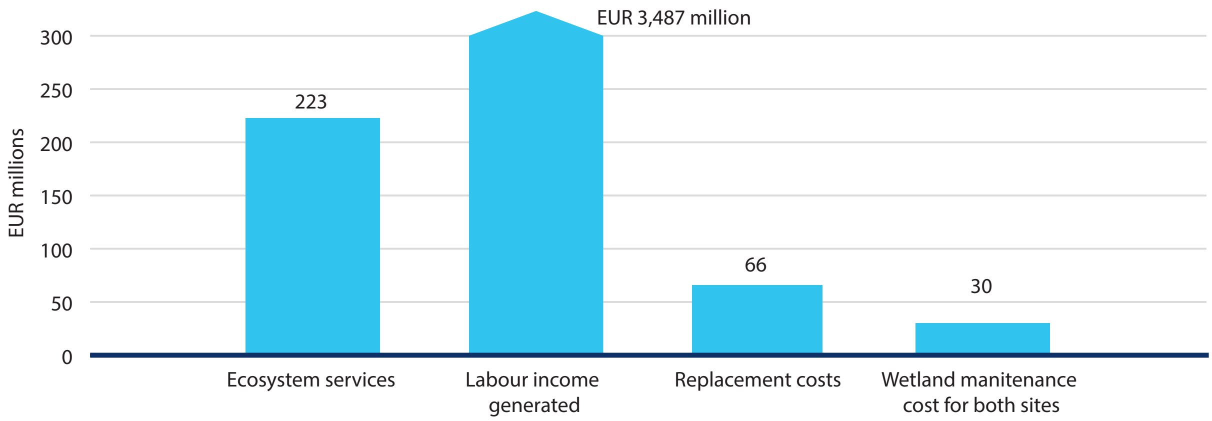

Figure 7. **Corru S'Ittiri-Marceddì-San Giovanni – Cumulative values over 40 years, continued degradation scenario**

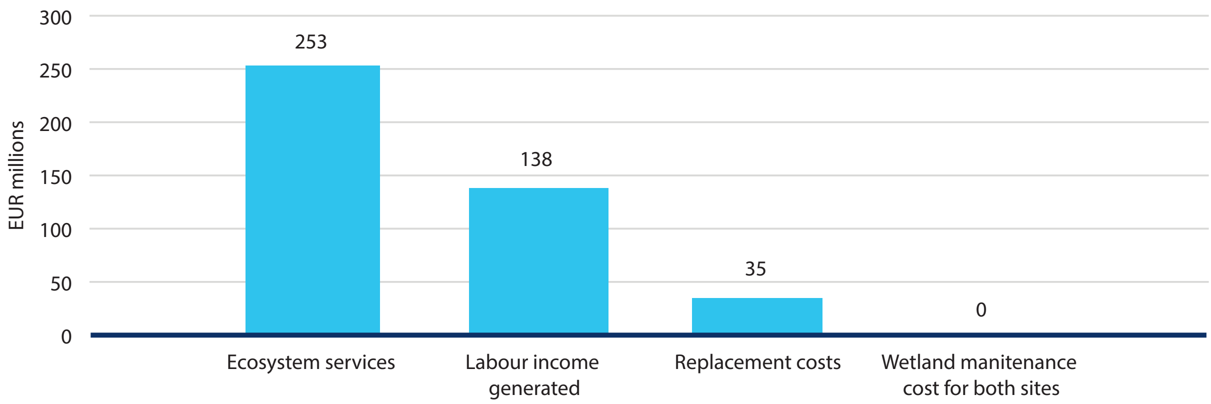

Figure 8. **S'Ena Arrubia – Difference in average annual values between the no degradation and continued degradation scenarios**

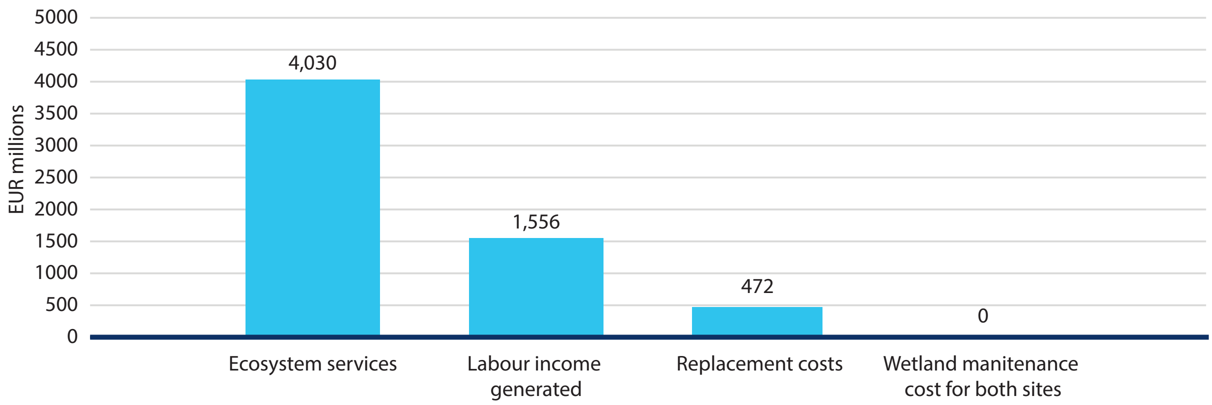

Figure 9. **Corru S'Ittiri-Marceddì-San Giovanni – Difference in average annual values between the no degradation and continued degradation scenarios**

5.2 Circular Business Opportunities: Reusing livestock manure

Stakeholders and local businesses in the wetlands of S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni requested this simulation after they read the preliminary valuations on the ecosystem services presented in this report. They were all particularly interested in the high ecosystem service values associated with nitrogen removal but also concerned about the extent to which nitrogen runoff was contributing to the degradation of the wetlands.

The key sources of nitrogen are livestock waste and chemical fertilizers. The simulation is thus based on the proportion of livestock manure that is reused in biogas digestion, as compost and as processed pellets, instead of being left to degrade on land. The full scope of assumptions is recapitulated below.

Table 25. Assumptions on circular business approaches in using livestock manure as fertilizer

Components	Assumptions
Cross-component assumptions	• 50% of the manure available will be collected and transformed into biogas, compost, or pellets. • Construction time of 3 years for the necessary production facilities. • Manure would replace 50% of the chemical fertilizers used currently.
Compost production	A hypothetical scenario, under which continued maintenance is undertaken, and the wetland quality does not degrade.
Pellet production	**S'Ena Arrubia** Share of manure composted: 20% **Corru S'Ittiri-Marceddì-San Giovanni** Share of manure composted: 35% **Both sites** Share of dry mass in compost: 47% Price (local): EUR 10/tonne Average production cost: EUR 39/tonne Price (export): EUR 120/tonne Cost of fertilizer: EUR 364/tonne According to Consorzio Italiano Compostatori (2017), the price of quality compost can be between EUR 5 and 15 per tonne. The difference in price is probably due to changes in transport costs, which are often paid by the composting plants. A significant part of the production cost is the cost of separation (EUR 32/tonne). We assumed that any manure that is not sold locally is exported

Components	Assumptions
Bioenergy production	**S'Ena Arrubia** Share of manure used for bioenergy: 30% **Corru S'Ittiri-Marceddì-San Giovanni** Share of manure used for bioenergy: 25% **Both sites** Energy content of poultry and pig manure: 0.45357 MWh/tonne Energy content of sheep and cattle manure: 0.09304 MWh/tonne Price of electricity from biogas: EUR 140/MWh Average production cost: EUR 132/MWh The proportion of manure used for bioenergy production was determined on the basis that it needs to cover the energy needs of pellet production, while generating some excess energy that can be sold. We assumed that biogas production yields a positive return of EUR 8/MWh produced.

This circular business opportunity is evaluated on the cumulative costs and benefits accrued between 2020 and 2060. The simulation is organized as follows:

- Section 2.1: Forecast of the investment costs as well as the operating and maintenance costs to set up production and logistics facilities to recycle and reuse the manure (Table 26 and Table 27).
- Section 2.2: Forecast of the avoided costs, namely, the avoided SCC and the avoided spending on chemical fertilizers made possible by the recycling and reuse of manure (Table 28 and Table 29).
- Section 2.3: Forecast of the added benefits, namely, revenues for the sale of processed manure, increases in labour income, and increased provision of ecosystem services (Table 30 and Table 31).
- Section 2.4: Summary of value generated by implementing the circular business opportunity to reuse manure for the production of biogas and as fertilizer (Table 32 and Table 33).

5.2.1 Forecast of the Investment Costs as Well as the O&M Costs to Set up Production and Logistics Facilities to Recycle and Reuse the Manure (Tables 26 and 27).

Tables 26 and 27 show the cumulative investment costs and the O&M costs of reusing the manure. There is no change in O&M costs for the wetlands, as the reuse of manure does not change the ongoing routine maintenance activities that take place in and around the wetlands. There is, however, the need for a capital injection to set up the production facilities and logistical arrangements to reuse the manure to produce bioenergy, compost, and pellets. In the case of S'Ena Arrubia, this is forecasted to be EUR 81.2 million; in the case of Corru S'Ittiri-Marceddì-San Giovanni, the forecast is EUR 106.7 million.

Table 26. Investment and O&M costs for the manure and continued degradation scenarios for S'Ena Arrubia

Investment and O&M costs (EUR) 2020–2040 cumulative values	Manure reuse scenario	No change, manure left to degrade on land
Investment and O&M costs		
Wetland maintenance cost (Introduced in section 1.5)	17,484,528	17,484,528
Capital cost	5,303,566	5,303,566
O&M cost	12,180,962	12,180,962
Compost production	13,602,169	0
Pellet production	41,922,981	0
Bioenergy production	25,643,417	0
Total investment and O&M costs	**116,137,623**	**34,969,057**

Table 27. Investment and O&M costs for the manure and continued degradation scenarios for Corru S'Ittiri-Marceddì-San Giovanni

Investment and O&M costs (EUR) 2020–2040 cumulative values	Manure reuse scenario	No change, manure left to degrade on land
Investment and O&M costs		
Wetland maintenance cost (Introduced in section 1.5)	17,484,528	17,484,528
Capital cost	5,303,566	5,303,566
O&M cost	12,180,962	12,180,962
Compost production	31,957,905	0
Pellet production	45,027,132	0
Bioenergy production	29,705,185	0
Total investment and O&M costs	**141,659,278**	**34,969,056**

5.2.2 Forecast of the Avoided Costs, Namely, the Avoided SCC and the Avoided Spending on Chemical Fertilizers Made Possible by the Recycling and Reuse of Manure (Tables 28 and 29)

Th avoided SCC is realized, as the simulation assumes that manure is no longer left on land to degrade. This, in turn, reduces nitrogen runoff, which subsequently increases the carbon sequestration capacity of the wetland.

The majority of the avoided costs come from the savings for farmers from using compost as organic fertilizer. The simulation assumes that farmers would replace 50% of chemical fertilizer use with compost and pellets. The savings realized are close to EUR 6 million for S'Ena Arrubia and EUR 14 million for Corru S'Ittiri-Marceddì-San Giovanni.

Table 28. Avoided costs for the manure and continued degradation scenarios for S'Ena Arrubia

Avoided costs (EUR) 2020-2040 cumulative values	Manure reuse scenario	No change, manure left to degrade on land
Avoided costs		
Avoided SCC due to carbon sequestration from the wetland	656,557	377,799
Avoided cost of fertilizers	5,924,500	0
Total avoided costs	**6,581,057**	**377,799**

Table 29. Avoided costs for the manure and continued degradation scenarios for Corru S'Ittiri-Marceddì-San Giovanni

Avoided costs (EUR) 2020-2040 cumulative values	Manure reuse scenario	No change, manure left to degrade on land
Avoided cost		
Avoided SCC from wetland	2,680,644	1,869,717
Avoided cost of fertilizers	13,919,443	0
Total avoided costs	**16,600,087**	**1,869,717**

5.2.3 Forecast of the Added Benefits, Namely, Revenues for the Sale of Processed Manure, Increases in Labour Income and Increased Provision of Ecosystem Services (Tables 30 and 31)

The main takeaways from the tables below are as follows:

- Significant net revenues can be earned through the circular economy business proposition. These revenues cumulate to EUR 160 million in S'Ena Arrubia and EUR 203 million in Corru S'Ittiri-Marceddì-San Giovanni.
- The improved wetland quality as a result of less nitrogen leakage strongly impacts the aquaculture sector. The resulting increase in labour income reaches EUR 4 million for S'Ena Arrubia and EUR 8.1 million in Corru S'Ittiri-Marceddì-San Giovanni.
- The value of all ecosystem services increases with the exception of the value of nitrogen removal, which decreases by EUR 13.3 million in S'Ena Arrubia and by EUR 10.7 million in Corru S'Ittiri-Marceddì-San Giovanni. The reason for this drop is that, with lower nitrogen loading in the wetlands, the value of nitrogen removal as a service decreases as well. This results in a drop in the total value of ecosystem services to EUR 7.9 million for S'Ena Arrubia. In the case of Corru S'Ittiri-Marceddì-San Giovanni, the total value still increases by EUR 4.8 million over the 20-year period.

Table 30. Added benefits for the manure and continued degradation scenarios for S'Ena Arrubia

Added benefits (EUR) 2020–2040 cumulative values	Manure reuse scenario	No change, manure left to degrade on land
Added benefits		
Revenue from manure	160,092,311	0
Revenue from compost sales	*22,670,280*	*0*
Revenue from pellet exports	*110,224,468*	*0*
Revenue from bioenergy	*27,197,563*	*0*
Labour income generated	994,623,336	990,558,834
Labour income from aquaculture	*9,573,085*	*5,508,583*
Labour income from tourism	*124,212,876*	*124,212,876*
Labour income from agriculture	*860,837,376*	*860,837,376*
Value of ecosystem services	32,271,559	40,183,843
Value of N removal	*19,687,844*	*32,942,856*
Value of amenity and recreation	*3,206,211*	*1,844,936*
Value of biodiversity	*1,394,571*	*802,468*
Value of flood control	*4,209,774*	*2,422,411*

Added benefits (EUR) 2020–2040 cumulative values	Manure reuse scenario	No change, manure left to degrade on land
Value of habitat nursery	*1,309,855*	*753,724*
Value of materials	*293,251*	*168,744*
Value of water filtration	*1,876,802*	*1,079,961*
Value of water supply	*293,251*	*168,744*
Total added benefits	**2,213,882,102**	**2,061,485,356**

Table 31. Added benefits for the manure and continued degradation scenarios for Corru S'Ittiri-Marceddì-San Giovanni

Added benefits (EUR) 2020–2040 cumulative values	Manure reuse scenario	No change, manure left to degrade on land
Added benefits		
Revenue from manure	203,154,617	0
Revenue from compost sales	*53,263,174*	*0*
Revenue from pellet exports	*118,385,945*	*0*
Revenue from bioenergy	*31,505,499*	*0*
Labour income generated	1,750,412,868	1,742,287,148
Labour income from aquaculture	*47,696,384*	*39,570,664*
Labour income from tourism	*224,966,852*	*224,966,852*
Labour income from agriculture	*1,477,749,632*	*1,477,749,632*
Value of ecosystem services	119,921,204	115,086,016
Value of N removal	*68,543,224*	*79,250,424*
Value of amenity and recreation	*13,090,580*	*9,130,562*
Value of biodiversity	*5,693,882*	*3,971,420*
Value of flood control	*17,188,104*	*11,988,496*
Value of habitat nursery	*5,348,012*	*3,730,173*
Value of materials	*1,197,311*	*835,113*
Value of water filtration	*7,662,781*	*5,344,715*
Value of water supply	*1,197,311*	*835,113*
Total added benefits	**3,943,822,761**	**3,714,746,327**

5.2.4 Summary of Value Generated by Implementing the Circular Business Opportunity to Reuse Manure for the Production of Biogas and as Fertilizer (Tables 32 and 33)

Tables 32 and 33 summarize the total value of the circular economy. The value addition can be observed as follows:

- After adjusting for the cost of production facilities, the circular business scenario generates a net benefit of EUR 81.3 million in S'Ena Arrubia and EUR 124.2 million in Corru S'Ittiri-Marceddì-San Giovanni.
- Through the sale of biogas, compost, and pellets, livestock farmers in S'Ena Arrubia can generate cumulative profits close to EUR 79 million and annual profits of EUR 2 million. In the case of Corru S'Ittiri-Marceddì-San Giovanni, livestock farmers would earn EUR 96.5 million in cumulative profit with annual profits of EUR 2.4 million.

Table 32. Difference in valuation between manure and continued degradation scenarios – S'Ena Arrubia

Integrated cost benefit analysis (EUR) 2020-2040	**Manure reuse scenario** difference compared to the prevailing scenario that assumes the manure is left on land to degrade
(1) Total investment and O&M costs	81,168,567
(2) Total avoided costs	6,203,258
(3) Total added benefits	156,244,529
Net benefit (2) + (3) - (1)	**81,279,220**

Table 33. Difference in valuation between manure and continued degradation scenarios – Corru S'Ittiri-Marceddì-San Giovanni

Integrated cost benefit analysis (EUR) 2020-2040	**Manure production scenario** difference compared to the continued degradation scenario
(1) Total investment and O&M costs	106,690,222
(2) Total avoided costs	14,730,370
(3) Total added benefits	216,115,526
Net benefit (2) + (3) - (1)	**124,155,674**

5.3 Direct Payments to Farmers for the Provision of Ecosystem Services

5.3.1 Rationale

This assessment has shown that the wetlands in S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni provide valuable ecosystem services such as water filtration, flood control, and nitrogen removal. If their degradation continues, local communities will suffer economic losses, or the government will have to invest in expensive built infrastructure in order to provide the same level of services. Therefore, anticipatory investments in the restoration and protection of the wetlands seem to be ecologically and economically worthwhile.

This section explores the case for re-targeting direct income support in the agriculture sector toward better environmental performance. The rationale is to reward farmers for delivering ecosystem services in the first instance. If farmers could receive incentives to deliver improved soils, cleaner water, lower greenhouse gases, and more biodiversity, expensive losses in ecosystem services—as well as future costs related to clean-up, remediation, and built solutions—can be avoided.

Current direct payments to farmers are usually calculated per hectare or head, with little or no consideration of environmental parameters. New payments could be tied to good performance related to ecological indicators such as nutrient balances or greenhouse gas emissions. This would incentivize farmers to use more sustainable farming methods. In the longer term, such incentives can, for instance, protect wetlands from degradation and secure the ecosystem services they provide.

5.3.2 Current Practice in Europe on Direct Payments in the Agriculture Sector

Prevailing practice indicates that farmers in Europe receive direct payments per hectare or per head, but recent reforms are moving in the direction of improved environmental performance.

Farmers in Switzerland, for example, are supported through direct payments similar to those through the Common Agricultural Policy (CAP) of the EU. The Swiss Agricultural Policy 2014–2017 reformed these payments to better meet policy targets such as biodiversity: instead of payments based on farm size or the number of cattle, farmers are increasingly compensated for the provision of public and ecological services (Organisation for Economic Co-operation and Development [OECD], 2017). The Swiss payments are subject to stricter conditions than in many other OECD countries. Since 1999, farmers have had to prove their ecological performance in order to receive the payments, for example, regarding a balanced use of nutrients and the allocation of ecological compensation areas (OECD, 2017). Apart from general direct payments, there is also a system for ecological payments that rewards, among others, organic farmers, extensive farming, or ecological compensation areas of different qualities (OECD, 2017).

In 2018, CHF 55 million was paid to organic farmers, with an average of CHF 350/ha and up to CHF 1,600/ha for special crops such as fruit or wine (Bundesamt für Landwirtschaft, 2019a). Swiss farmers are also supported with CHF 400/ha for the extensive farming of certain crops, such as cereals or rapeseed (Bundesamt für Landwirtschaft, 2019a). Farmers choosing extensive farming do not use fungicides, insecticides, or growth regulators and therefore run a certain risk of a reduction in yield or even the loss of their harvest. This risk is reduced through direct payments. The program on resource efficiency includes payments for farmers who adapt the feeding of the pigs to their current nutrient demand in order to reduce nitrogen loadings in the manure (Bundesamt für Landwirtschaft, 2019b).

Environmental performance is also targeted in the U.K. Agriculture Bill 2019–2021. The bill is currently in the reading process and will eventually govern the United Kingdom's agricultural subsidies, once the United Kingdom's post-Brexit transition period ends on December 31, 2020. Until now, the United Kingdom has been part of the Common Agricultural Policy, given the country's former status as an EU member state. Direct payments to farmers under the CAP scheme are presently calculated per hectare or head, adding up to around GBP 3.5 billion. Beginning in 2021, these income support payments will be phased in over a period of seven years. The new British subsidy scheme will pay farmers for producing public goods such as environmental or animal welfare improvements. The 2019–2021 bill includes new measures, for example, relating to fertilizer regulation. The bill also includes a list of purposes that are eligible for financial support, for instance, measures to better manage climate-related risks, improve animal health and welfare, promote soil protection and improvement, or minimize the negative environmental impacts of agricultural production (Agriculture Bill, 2020; Coe et al., 2020).

Italian farmers receive income support payments through the CAP of the EU. While the average payment in 2015 was about EUR 400/ha in Italy and EUR 266/ha in the EU (European Commission & Directorate-General for Agriculture and Rural Development, 2017), farmers in the Province of Arborea, Sardinia, receive between EUR 300 and 800/ha. Thirty per cent of the aid, known as direct green payments or greening, is only paid if the farmer implements certain measures to protect the environment, for example, crop diversification and the allocation of 5% of the arable land to ecological areas. Farmers receiving CAP support have to respect EU rules on public, animal, and plant health; animal welfare; and the environment, as well as EU standards on good agricultural and environmental condition of land ("cross-compliance") (European Commission & Directorate-General for Agriculture and Rural Development, 2017). The cross-compliance system is reported to be lacking in Sardinia, as monitoring activities focus more on the documents, machinery, and tools than on the water or soil quality on the farm.

BOX 3. MEASURING (BIODIVERSITY) PERFORMANCE: BIODIVERSITY MONITOR FOR THE DAIRY FARMING SECTOR

Tying direct payments to ecological performance can motivate farmers to invest in sustainability, but quantifying this performance proves to be difficult. In 2018, FrieslandCampina, Rabobank, and WNF (the Dutch chapter of the World Wide Fund for Nature/WWF) published a tool to quantify the biodiversity achievements of Dutch dairy farms. The dairy farmers could be rewarded for their ecological performance based on these quantifications.

Agriculture is a large consumer of land in most countries. In the Netherlands, the dairy sector is the major land user, which makes the dairy farming industry an important player in biodiversity protection. Improving the management of the landscape and the natural environment can significantly increase the conservation of species that are dependent on the agricultural landscape. Additionally, biodiversity has direct impacts on agricultural productivity. Dairy farmers depend on natural resources such as fertile soil and clean groundwater. The support of functional biodiversity, such as soil organisms, contributes to healthy soils and therefore boosts productivity.

The Biodiversity Monitor for Dairy Farming uses so-called Key Performance Indicators (KPIs) to measure the influence of dairy farms on biodiversity. This way, the role of dairy farmers in the preservation of the landscape and the environment can be monitored through a standardized system. The KPIs constitute an integrated set that collectively reflects the farm's biodiversity performance. One example of a KPI is the percentage of permanent grassland (percentage of total acreage). Grassland is beneficial, for example, for organic matter in the soil and ultimately also for environmental functions such as water regulation and avoiding emissions into water. Another KPI used in the biodiversity monitor is the nitrogen soil surplus (nitrogen soil surplus in kg of nitrogen per hectare). Nitrogen runoff into the water contributes to eutrophication and can compromise ecosystem services. In the biodiversity monitor, the nitrogen surplus in the soil is used as an indication of the burden on the soil and water system.

The other indicators suggested in the Dutch biodiversity monitor are:

- Percentage of protein produced by own farm/in farmer's own region
- Ammonia emissions (NH_3) in kg/ha
- Greenhouse gas emissions (kg CO_2e/ha and /kg of milk)
- Percentage of herb-rich grassland
- Nature and landscape (percentage of managed land based on management contract)

For further details, see the biodiversity monitor (van Laarhoven et al., 2018).

Source: van Laarhoven et al., 2018.

5.3.3 Making the Case for Direct Payments for Environmental Performance in Agriculture

This assessment has estimated the value of the ecosystem services provided by the wetlands in S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni. In S'Ena Arrubia, the wetlands used to provide ecosystem services worth EUR 135/ha/year in 2000. Wetland degradation has slightly decreased the value of ecosystem services to EUR 120/ha/year in 2020. In Corru S'Ittiri-Marceddì-San Giovanni, the wetland provided ecosystem services worth EUR 320/ha/year in 2000. Due to wetland degradation, the value declined by EUR 87, to EUR 234/ha/year in 2020.

Studying these values, we observe that the value of the EU average of direct payments to farmers, EUR 266/ha/year, is comparable to that of the value of the ecosystem services by the wetlands. Indeed, farmers in the Province of Arborea (where the S'Ena Arrubia and Corru S'Ittiri-Marceddì-San Giovanni wetlands are located) are reported to receive higher payments of EUR 300–800/ha/year (see Table 34).

These payments are only marginally linked to the farm's environmental performance. Tying at least parts of the income support to the implementation of measures protecting the wetlands could incentivize more sustainable farming practices and local investments.

Table 34. Value of ecosystem services compared to the direct payments received by farmers

Wetland sites in Oristano, Province of Arborea	Value of ecosystem services delivered EUR/ha/year in 2020	Direct payments received by farmers located in the Province of Arborea EUR/ha/year
S'Ena Arrubia,	120	300–800
Corru S'Ittiri-Marceddì-San Giovanni	234	300–800

6.0 Raising Financing for the Continued Preservation of the Wetland

The valuation of environmental, social, and economic externalities is an essential component of mobilizing financing into wetlands. As sustainable investing is gaining traction, both public and private actors are increasingly seeking out investment opportunities with a strong impact profile. This is an excellent opportunity for upscaling the financing of nature-based solutions. However, any investor interest will be subject to the availability of some forms of revenue streams and a credible assessment of the environmental and social footprints of the project. SAVi applications generate quantitative evidence that supports both of these areas. Our valuations enable the structuring of various conservation finance instruments by monetizing the infrastructure services provided by these wetlands. This can be the basis for identifying the revenue streams needed for channelling more resources into these projects.

So how will this assessment help to raise financing for the restoration and maintenance of these lagoons? First, it provides the necessary arguments for governments that, even from a purely economic perspective, wetland maintenance is a good investment. Increased economic activity increases employment, decreases taxpayers' reliance on public support, and generates tax revenues. With this information, governments can also align their spending to one or all of the valuation approaches in this assessment.

In addition, local governments are encouraged to explore the use of "tax increment financing" (TIF) to fund any additional spending on wetland restoration. This structure relies on the assumption that improvements in wetland quality result in higher economic activity. Our results demonstrate that this is indeed the case for the two wetland sites assessed. TIF requires the setup of a dedicated fund that could be shared across different municipalities. Any additional tax income revenue generated as the result of an improvement in wetland quality is channelled into this fund. The amount of tax revenue can be determined based on our calculations outlined in this report or other similar assessments. The TIF funds can be tapped by local or regional governments to provide further support to wetlands in the Gulf of Oristano or other parts of Sardinia.

Additional financing could also be raised for the wetlands through a sustainability-linked loan structure; these have experienced exponential growth in recent years. In this case, the cost of borrowing for the local business is linked to the actions it takes to maintain the wetland in its proximity. If the business does not meet a predetermined set of sustainability performance indicators, it has to pay higher interest on its sustainability-linked loans. This way, the company would have a double incentive to ensure wetland quality: (i) it determines its cost of financing and (ii) it enables revenue generation through provisioning the ecosystem services that its operation relies on. This incentive structure will result in businesses becoming active stewards of the wetlands while mobilizing more corporate spending on their restoration and maintenance.

Another way to raise financing for the continued preservation of the wetland is by selling carbon offsets on the voluntary carbon markets. As also demonstrated in this assessment, healthier wetlands can capture more carbon. In other words, with more resources for restoration and maintenance, the ability of wetlands to sequester carbon can improve in a measurable manner. The issuance of carbon offsets would require certification by a relevant standard provider such as VERRA or the Gold Standard. This SAVi assessment provides the fundamentals to approach these voluntary schemes.

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Annex A. Methodology of IISD's Sustainable Asset Valuation (SAVi)

The Need for a System-Based Approach

Assessing the value of an infrastructure asset—be it natural or built—is complex. In particular, natural infrastructure often provides ecosystem services that may enable economic activity, strengthen social empowerment and well-being, and further support ecological integrity. As a result, any analysis of natural infrastructure has to assess impacts (i) across dimensions of development (i.e., social, economic and environmental), (ii) across economic sectors, (iii) across economic actors (e.g., households, public and private sector), (iv) over time, and (v) in space.

The SAVi model was developed using the system dynamics methodology (Sterman, 2000). Its core pillars are feedback loops, delays, and non-linearity. These are explicitly represented in the model using stocks and flows, which are solved with differential equations. The SAVi model has been developed based on global literature, is customized with local stakeholder input and is parametrized with local, accessible data. The model simulates from 2000 to 2060. There are two main reasons for using this specific time frame: (i) being causal–descriptive, SAVi needs to be validated against historical data (hence the simulation of the model from 2000 onwards) and (ii) being focused on infrastructure and long-term interventions (and their costs and outcomes), SAVi needs to forecast the impacts of interventions after they have been implemented and are fully operational.

Method: Systems thinking

The key variables and main drivers for the assessment of nature-based and built infrastructure were analyzed and summarized in a causal loop diagram (CLD). The CLD includes the main indicators analyzed; their interconnections with relevant components related to the use of infrastructure, such as total area and ecosystem/infrastructure services provided; and the feedback loops they form. Capturing feedback allows one to see the asset as part of socioeconomic and environmental subsystems and allows for inferring direct and indirect impacts. The CLD was developed and customized to the local context in collaboration with local stakeholders, who also provided the necessary information for the assessment. The CLD is the starting point for the development of the mathematical stock and flow model.

Designing a CLD for a project helps to combine and integrate a team's knowledge, ideas, and concepts. Moreover, an interactive CLD design and verification process with the key stakeholders of a project ensures that these stakeholders have a common understanding of the analysis being undertaken, both in terms of its overarching scope and its underlying factors. This will then enable these stakeholders to later appreciate and make use of analysis results (Pittock et al., 2016; The Economics of Ecosystems and Biodiversity, 2018). In this regard, CLDs highlight the root causes of a problem, as well as the variables of a system that could, with the appropriate technical or policy interventions, be targeted to develop solutions (United Nations Economic Commission for Africa, 2018).

To design solution-oriented and effective interventions, CLDs need to capture the causal relations of a system correctly. Therefore, CLDs establish causal links between variables by linking them with arrows and attributing a sign to the arrow (either + or −) that indicates whether a change in one variable generates a positive or negative change in the other.

As noted by Bassi et al. (2016):

- "A causal link from variable A to variable B is positive if a change in A produces a change in B in the same direction.
- A causal link from variable A to variable B is negative if a change in A produces a change in B in the opposite direction."

Table A1. Causal relations and polarity

Variable A	Variable B	Sign
↑	↑	+
↓	↓	+
↑	↓	-
↓	↑	-

Moreover, these causal interactions can form what is known as a positive or negative "feedback loop" (Forrester, 1961). In other words, an intervention made in that system can either support the tendency toward equilibrium within the overarching system, in which case this negative feedback loop is called a balancing loop. Alternatively, an intervention can reinforce the intervention's impact and, hence, create a positive feedback loop, which is called a reinforcing loop (Bassi, 2009; Forrester, 1961). What makes CLDs especially useful for decision-makers and other stakeholders is this feedback component, showing how the different elements within a system interact with each other and either exacerbate or ameliorate a given situation (The Economics of Ecosystems and Biodiversity, 2018). These mapped relationships may not necessarily indicate linear behaviour, and potential impacts may occur after a delay, which is why a CLD that captures the extent and complexity of this system is important. The interaction of "feedback loops" may also be where the source of a given policy problem lies. This is where decision-makers will need to direct their efforts for finding a solution while simultaneously being aware of how this solution will affect the rest of the system (WWF, 2014).

Annex B. Manure Recycling

Animal manure contains valuable nutrients and can be used and recycled in various ways; for example, it can be applied to land directly, transformed into compost, dried into pellets, or used to produce biogas.

Separation

Manure and slurry can be separated into solid and liquid fractions, for example, through filtration or centrifugation. This produces a phosphorus-rich solid fraction and a relatively nitrogen-rich liquid fraction (Nolan et al., 2012). The nitrogen-rich liquid fraction is usually applied to land in the proximity of the farm, while the solid fraction can be transported for longer distances for the application on tillage land elsewhere. The separation is also an important step for other ways to recycle manure, such as composting or pelleting.

Biogas

Biogas is a mixture of methane, carbon dioxide (CO_2), and other gases produced by anaerobic digestion of organic matter. Biogas can be used directly to produce electricity and heat or as an energy source for cooking. The methane content of biogas typically ranges from 45% to 75% by volume, with most of the remainder being CO_2. By removing the CO_2 and other gases, the biogas can be upgraded into biomethane. Biomethane is indistinguishable from natural gas, which means it is fully compatible with the existing infrastructure for natural gas and can even be used in natural gas vehicles. The global average cost of producing biomethane through biogas upgrading today is around USD 19 million/ British thermal units (International Energy Agency, 2020).

The energy content of the organic matter used as the feedstock is a key factor in the productivity of biogas production plants. The energy content of animal manures is significantly smaller than in other feedstocks such as crop residues or municipal solid waste (International Energy Agency, 2020). In order to increase productivity, manure can be combined with other organic matter ("co-digestion").

The leftover digestate from the biogas production can be processed into pellets, which can be used as heating fuel or organic fertilizer (Nagy et al., 2018). It is possible to use part of the waste heat from the biogas plant to dry the pellets.

There are several small private anaerobic digesters in Sardinia that produce biogas from the manure produced by the local livestock; one of them is located in Arborea. The dairy sector cooperative has invested in a biomethane power plant with a denitrification appliance. The collected nitrogen is to be sold to produce (pelletized) fertilizers that can be marketed nationwide.

Drying and Pelleting

The aim of drying manure is to produce a dried, stable, and odourless product that contains most of the nutrients, is easier and cheaper to transport, and can be spread as an organic fertilizer on land. The thermal energy needed for drying the manure is usually recovered from combined heat and power engines or other heat residual streams. Pellets can be produced from solid manure (such as poultry litter), manure compost, or the solid fractions from the separated slurry or biogas digestate (Flotats et al., 2009; Nagy et al., 2018; Sommer et al., 2013).

Dried manure pellets contain about 19 kg/tonne of nitrogen, 39 kg/tonne of phosphorus, and 43 kg/tonne of potassium (Foged et al., 2011). Pellet prices vary significantly between EUR 0 and 200/tonne, with prices depending mainly on the packaged amount, the content, and the season (Nagy et al., 2018). Research suggests that the most profitable use for pellets from biogas plant digestate is to sell them as heating fuel (Nagy et al., 2018).

(Vermi-)Composting

Composting

Aerobic composting reduces the mass of the manure and produces a stabilized, value-added product that is cheaper to transport and easier to handle and apply. Composting also eliminates pathogens and weed seeds and reduces the risks of odour and gaseous emissions after application. For composting, the manure is usually piled up into windrows, and the material is turned regularly. Often the manure is separated into the solid and liquid fractions using filters or centrifuges before composting the solid parts. The manure can also be mixed with other organic materials prior to composting (Sommer et al., 2013). Compost contains about 14 kg/tonne of nitrogen, 7 kg/tonne of phosphorus, and 13 kg/tonne potassium and is mostly sold to garden owners, grape growers, and horticulturists (Foged et al., 2011).

The existing composting plants in Sardinia are currently processing the municipal organic waste but no animal manure.

Vermicomposting

Manure and other organic materials can be transformed into vermicompost by earthworms, as is done by one facility in Sardinia. Vermicompost is particularly rich in plant nutrients, microbial life, and humus and is a valuable fertilizer and growth medium in horticulture. Vermicomposting is faster than composting in windrows and yields not only compost but also increased earthworm biomass. Earthworms can be used as a protein feed supplement for livestock and aquaculture (Edwards, 1985, 2011; Haitao et al., 2018).

SAVi Sustainable Asset Valuation

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