Biovert Protein Co., Ltd.

Business Context

A steady increase in the international production and consumption of fish has positioned aquaculture as a development opportunity. Aiming to promote a more sustainable and circular aquaculture production process, Biovert Protein Co., Ltd, a start-up based in Bangkok, Thailand, has designed an innovation that enables the nutrients usually discharged in aquaculture wastewater to be upcycled into energy dense and protein packed living fuel that can replace unsustainable commercial fish feed. They call this innovation Biovertical Unlock [TM], and two nature-based keys make it possible:

1) Micro Nano Bubble (MNB) technology to improve the aeration and water quality of pond water and enable the removal of organic waste.
2) Black soldier fly (BSF) larvae reared on the recycled aquaculture organic waste to act as a sustainable protein alternative used in commercial fish feed.

Together, these two innovations offer multiple improvements to existing aquaculture practices. In comparison to the dominant paddle-wheel aerators used in aquaculture farms, MNB aerators have higher oxygen transfer, lead to better farm water quality, reduce disease outbreaks, and remove the need to discharge polluted wastewater into nearby water sources.

Meanwhile, upcycling organic waste into insect protein offers an alternative used in commercial fish feed, which is typically made from a combination of fish meal and soybean meal, neither of which can be scaled sustainably to meet the growing demand. Fishmeal is especially damaging because every kg produced requires 5kg of wild pelagic fish, and the negative impacts associated with overfishing these smaller fish species has knock-on effects for the entire ocean biome. Moreover, while often presented as a sustainable alternative, soybean meal is mostly grown on deforested lands of the Amazon and is therefore contributing to both climate change and biodiversity loss.

Through its Biovertical Unlock innovation, Biovert sustainably develops aquaculture from linear into circular nature based systems. While existing systems (Figure 1) take natural capital inputs (fish meal / soybean meal), turn them into produced capital (farmed fish / shrimp), and discharge contaminated waste outputs back into natural assets (local water supply), the Biovert innovation closes the loop on this process by turning the waste outputs into inputs (Figure 2).

Figure 1 – Existing Approach

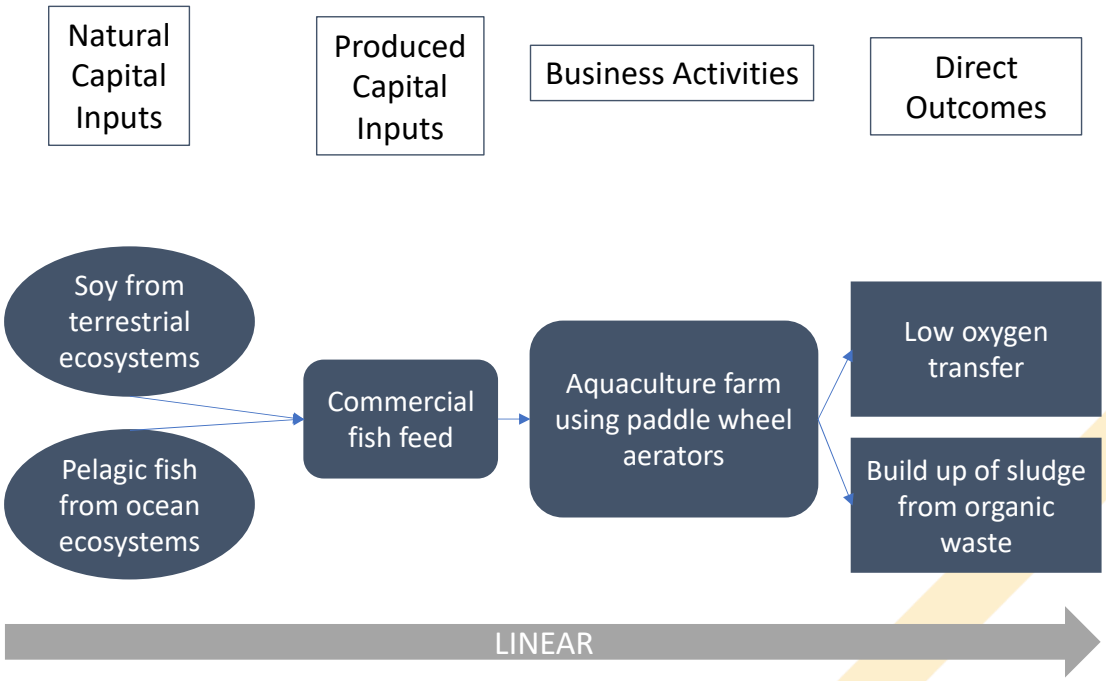
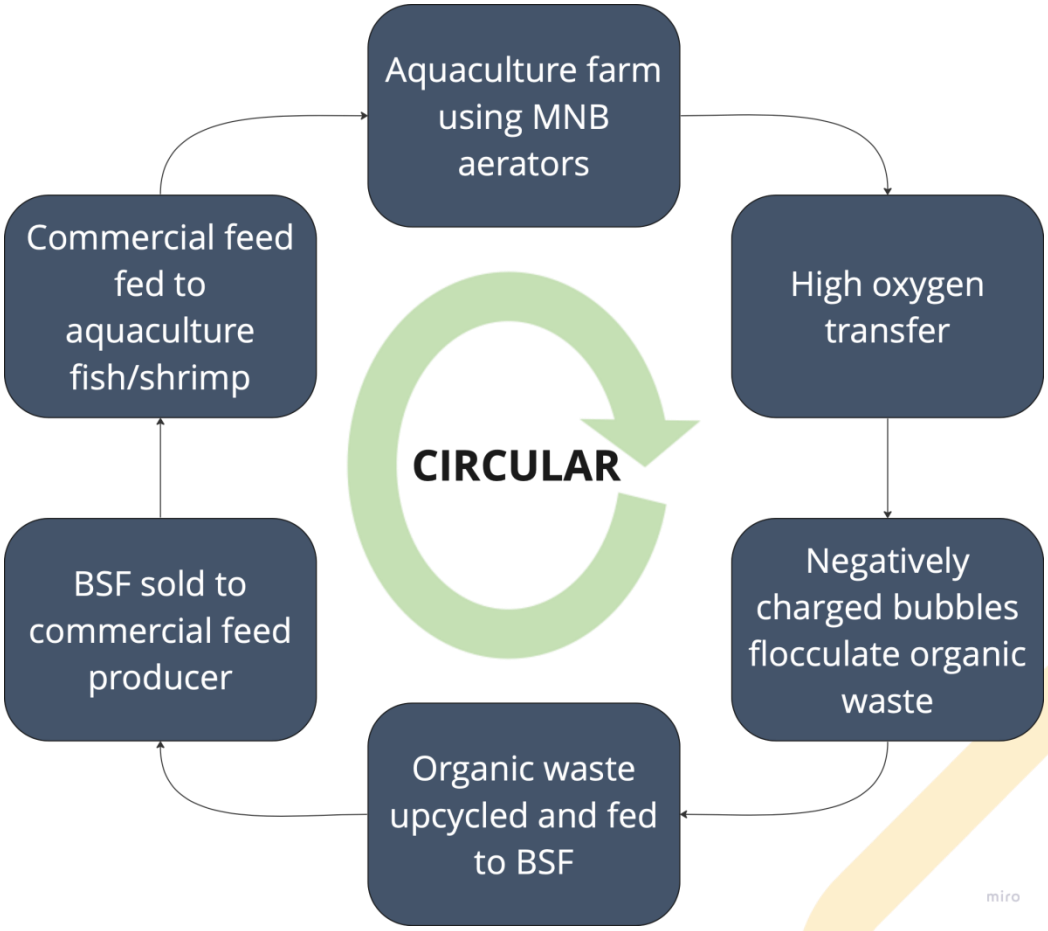


Figure 2 – Biovertical Unlock Innovation



With this circular model, Biovert aims to initiate a shift towards a more sustainable form of aquaculture in the Lower Mekong River Basin (LMB), where the Biovert Innovation will first be rolled out. If made more efficient and sustainable, aquaculture can act as an alternative to the currently dominant yet unsustainable inland capture fisheries operating in the LMB, a region that is facing multiple overlapping challenges associated with the proliferation of hydropower dams and climate change.

In addition to the environmental benefits, Biovert expects its innovation to reduce exposure to waterborne disease risk, increase the household income for LMB farmers who adopt the solution, and provide another source of income for local women Kai foragers, whose livelihoods are being put at risk by the negative impacts that hydropower dams are having on this freshwater plant food staple.

Assessment

WHY? What was the objective of the assessment?

The overarching aim of the capitals assessment is to demonstrate that the Biovert intervention is a cost effective, financially viable alternative to existing aquaculture production processes while providing additional social and ecological value. However, Biovert is still a pre-launch start-up that has received an initial round of

investment but is not yet operating. A key objective of the assessment is therefore to strengthen its 'proof of concept' pitch for further investment, which it will use to fund a demonstration pilot in Northern Thailand. This multi-capitals assessment (MCA) therefore comprises two stages.

The first is a high-level, preliminary desk-based assessment **(High-Level Assessment)** applied to the proposed Biovert intervention that will help inform Biovert's 'proof of concept' and will be used to:

- Highlight the nature and indicative relative value/significance of potential impacts that the Biovert intervention is expected to lead to.
- Provide evidence to strengthen Biovert's business case and help to target and inform impact investors so that funding can be obtained to initiate a demonstration pilot.

The second will be a more detailed MCA **(Detailed Assessment)** of the demonstration pilot when it is implemented, using actual site data and information collected as part of the demonstration project. The results from this stage will be used to:

- Assess and further build evidence on the operational, legal & regulatory, financial cost effectiveness and societal opportunities &/or risks that the interventions provide.
- Demonstrate using actual project data and information that the targeted interventions create greater value to nature and people when compared to commonly used competitor technology.
- Target impact investors & regulators to maximise stakeholder support to help scale up investable gender-responsive climate smart aquaculture solutions within the LMB.

WHAT? What was the scope of the assessment?

Biovert opted to conduct an ambitious multi-capitals assessment, factoring in impacts across all four capitals. The scope of the assessment is effectively a 'with/without' scenario comparison, where the impacts the Biovertical Unlock intervention has across the four capitals are compared with the baseline of the current situation under the existing approaches.

The baseline is therefore aquaculture farms using commercial fish feed (mainly consisting of pelagic fish and soy) as a feed source and mechanical rotating paddle wheels for aeration. The scenario is the introduction of Biovert's two interconnected nature-based innovations – the MNB aerators and the BSF protein meal produced from BSF larvae reared on the aquaculture waste that the aerators make it possible to extract.

The value-chain boundary of the assessment is primarily the direct operations and its consequences to the business and to communities in the local area. However, there

is also an 'upstream' element in relation to the sourcing of key ingredients used in commercial aqua-feed (fish meal produced from pelagic fish and soybean meal produced from soya grown in the Brazilian Amazon) in the existing 'without project scenario'.

The type of value used will depend on the stage of the assessment, and which intervention is being assessed in relation to which capital. The high-level assessment is primarily qualitative (High, Medium, Low impact) supplemented by some quantitative and monetary value-based narrative. The detailed assessment will involve both qualitative (e.g. from interviews, surveys, workshops), quantitative (e.g., energy consumption, effluent load) and monetary (cost savings and value-transfers) values.

For the high-level assessment, Biovert has worked with a consultancy to carry out the assessment. Their expertise in natural/multi capital impact valuations ensure the results are credible and enable Biovert to strengthen their business pitch. In addition to desk-based literature research and data analysis, Biovert's sector and site-specific knowledge has been drawn upon to estimate impacts across the capitals. This stage has been completed by August 2023, when the results were presented at a TEEB-Agri conference in Bangkok.

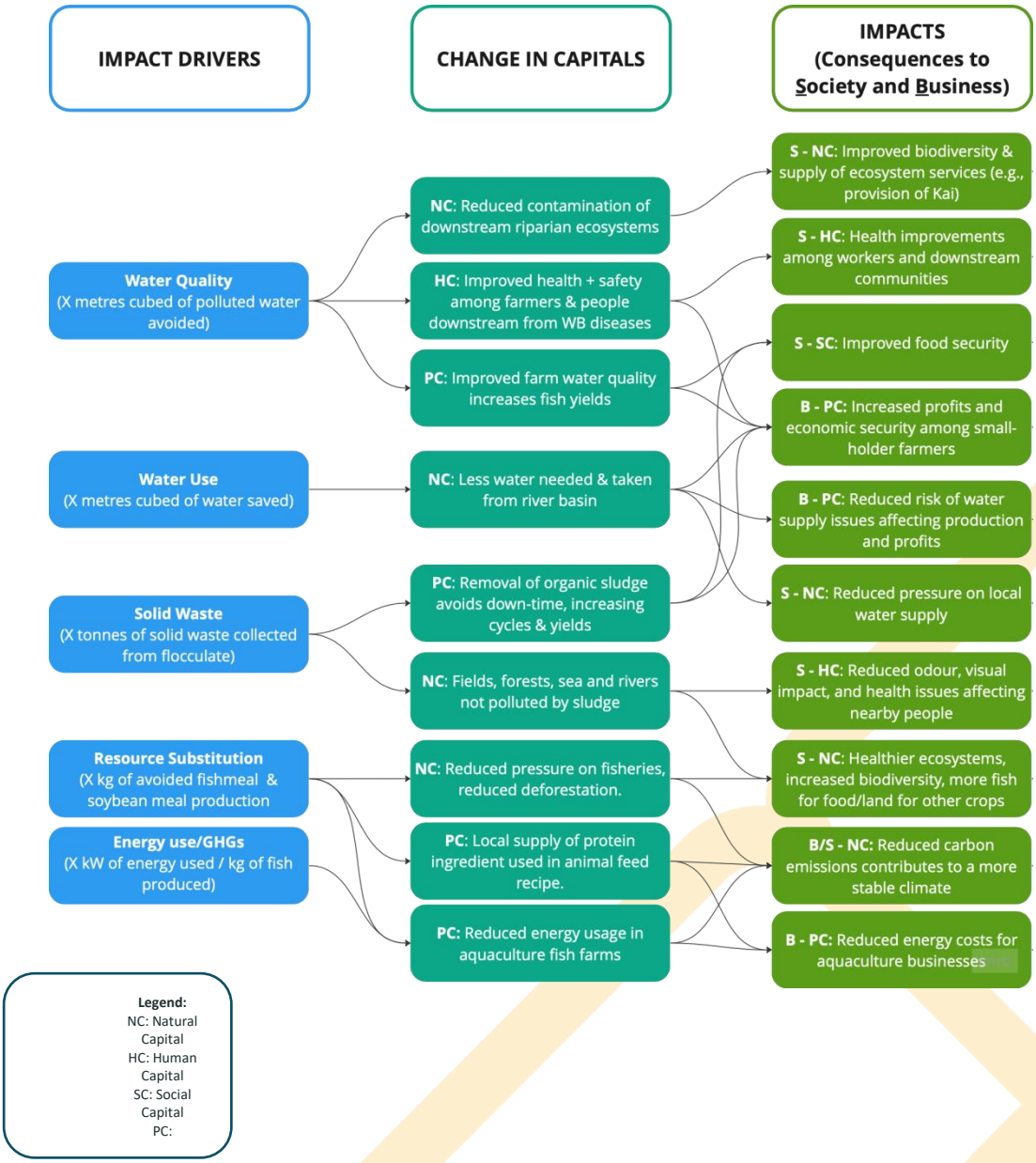
The detailed assessment will require considerably more time and expertise as it will involve primary on-site data collection. The pilot will take place in the North-Eastern region of Thailand (Chiang Rai and Chiang Mai in the LMB) and is expected to extend over a period of 20 months. The MCA will cover the same duration because tests, interviews, and other data collection techniques will ideally need to be carried out prior to, during, and after the pilot to be fully representative. Technical support will likely be needed to help undertake the surveys and complete the valuation components.

The spatial boundary of the assessment includes the aquaculture sites (in Chiang Rai) and the downstream water bodies (canals/rivers/lakes) that wastewater effluent is currently discharged into. The sources of the natural capital aqua-feed inputs in the 'without scenario' are also included, i.e., the pelagic fish, which mainly comes from South America – (especially Peru and Ecuador) and the soya, which mainly comes from Brazil.

HOW? What was measured and valued?

Biovert conducted a materiality assessment and selected its 5 most material impact drivers. It then mapped the impact pathways from each of these, indicating how they lead to a change in capitals, and how these changes have consequences to both society and the business. The results from this mapping exercise are displayed in Figure 3. While all 5 impact drivers are in the realm of natural capital, the fact that these lead to changes and consequences across all four of the capitals highlights the interdependent relationship among natural, social, human, and produced capital.

Figure 3 – Impact Pathways



With these impact pathways mapped, the next stage was to determine how they would be measured and valued. The approach for this stage (Steps 5, 6 and 7) differs between the high-level and detailed assessments, because while the former is based purely on desk-based research, professional judgement and sector-specific knowledge, the latter involves primary data collection from the demonstration pilot, thereby expanding the possible measurement and valuation techniques.

The approach taken for the detailed assessment is set out below in Table 1. Where possible, a technique for monetary valuation has been outlined. However, some of the consequences, such as the improved food security, would be challenging to value

monetarily. In any case, if taken to completion, the approach set out here would help Biovert to meet its objectives by providing evidence on the additional value (across all capitals) the Biovertical Unlock innovation offers compared to existing approaches. This information would allow Biovert to target impact investors & regulators to maximise stakeholder support to help scale up the business in the LMB.

The approach and results from the high-level assessment are set out in the next section.

Table 1 – Approach for Detailed Assessment

Material impact driver and indicator	Change in capitals resulting from the impact driver	Consequences of impact drivers on business (b) or society (s)	Type of valuation and technique
1.Water Quality *(No of output water pollution incidents)*	**NC**: Reduced contamination of riparian ecosystems	**S**: Improved supply of ecosystem services (e.g., provision of Kai)	**Qualitative**: Challenging to determine a biodiversity valuation metric for this - potentially the maintained financial value (net profit) of kai fishing (but need to disaggregate cause-effect impacts - so qualitative only)
		B: Fines/penalties for farmers to have to pay for pollution incidents if prosecuted	**Monetary**: The valuation of the potential monetary impact is the cost avoided of potential fines/penalties for exceeding the effluent discharge limit.
	HC: Improved health + safety among farmers & people downstream from WB diseases	**S**: Health improvements among workers and downstream communities	**Monetary**: Number of DALY losses avoided by farmers & by local communities x US$/DALY based on with/without data
	PC: Improved farm water quality increases fish yields	**S**: Improved food security as sustainable clean farm water will increase farm yield and intensification of farming	**Monetary**: Comparison in Farm Yield (Total Harvest Kg & $; Productivity (kg/m3 & $/m3)) with and without intervention
2.Water Use *(Volume of water used)*	**NC**: Less water needed & taken from river basin	**B**: Increased profits and economic security among small-holder farmers	**Monetary**: Net revenues gained - Discounted cash flow (DCF) calculation based on best estimate projections of financial costs and revenues and
		B: Reduced risk of water supply	

		issues affecting production and profits	probabilities of occurrence (i.e. expected values). Potentially too challenging and time consuming to obtain the information to do this.
		S: Reduced pressure on local water supply	**Monetary**: Savings in value of water (volume of water saved x $/m3 water) - using value transfer for value of water
3.Solid Waste *(Quantity of solid waste removed)*	**NC**: Fields, forests, sea and rivers not polluted by sludge	**S**: Reduced odour, visual impact, and health issues affecting nearby people - Difficult to evaluate	**Qualitative**: Social impacts (odour, visual, health) - qualitative only.
		B: Avoided solid waste disposal costs to s/h farmers ($)'	**Monetary**: Costs avoided from otherwise having to dispose of the sludge.
	PC: Removal of organic sludge avoids down-time, increasing cycles & yields	**B:** Increased profits and economic security among small-holder farmers	**Monetary**: Comparison of production uptime (time and $) and output (Kg and $) per annum with and without intervention
4. Resource Substitution *(Amount of fish meal or soybean meal protein replaced / kg of fish feed produced)*	**NC**: Reduced pressure on fisheries, reduced deforestation.	**S**: Healthier ecosystems, increased biodiversity, more fish for food/land for other crops	**Qualitative:** Evaluated through discussion with fishmeal and soybean meal providers & others as necessary
	PC: Local supply of protein ingredient used in animal feed recipe.	**B:** Reduced costs of production ($/ton) for aquatic/animal feed products	**Quantitative / Monetary**: Comparison of amount of imported fish meal and soybean meal replaced with local insect protein and associated costs saved (Kg and $)
		B/S: Reduced carbon emissions from using local protein alternative contributes to a more stable climate	**Quantitative**: Calculation of avoided CO2 Emissions per tonne of product - based on distance and transport type avoided
5. Energy Use/GHGs	**PC**: Reduced energy use in MNB aeration	**B**: Reduced energy use costs	**Monetary**: Reduced costs from energy usage ($/kg product)

(Energy Use per hour / Kg product)		**S:** Reduced carbon emissions & global warming	**Monetary**: Value transfer of $/ton carbon saved

WHAT NEXT? What were the results of the assessment?

As mentioned, the high-level assessment employed desk-based research, professional judgement, and sector-specific knowledge to estimate a qualitative impact rating for each of the step 7 consequences. Each consequence was rated as either Low, Medium, or High in relation of their potential impact to either society or the business. Where possible, this score is based on evidence from other research studies that investigate related production processes and/or changes in capitals in similar locations.

For example, in relation to the water quality impact driver, several studies were drawn upon to understand the typical material contents of aquaculture effluent and the health impacts these materials can lead to when discharged into water supplies. One study also used the willingness to pay method to estimate the monetary value of cleaning up a river in the same Northern Thailand region. Since the Biovert innovation will contribute to a reduction in freshwater pollution, a portion of this value can be transferred to help estimate Biovert's potential impact through this pathway.

The summarised results from this process are displayed below in Table 2.

Table 2 – Approach and Results from High-Level Assessment

Material impact driver or dependency	Change in capitals resulting from the impact driver/dependency	Consequences of impact drivers or dependencies on business (b) or society (s)	Value
1.Water Quality *(Typical organic matter content of aquaculture effluent)*	**NC**: Reduced contamination of riparian ecosystems	**S**: Improved supply of ecosystem services (e.g., provision of Kai)	L/M
	HC: Improved health + safety among farmers & people downstream from WB diseases	**S**: Health improvements among workers and downstream communities	M/H
	PC: Improved farm water quality increases fish yields	**S**: Improved food security	M

2.Water Use *(Volume of water used)*	**NC**: Less water needed & taken from river basin	**B**: Increased profits and economic security among small-holder farmers	M
		B: Reduced risk of water supply issues affecting production and profits	M
		S: Reduced pressure on local water supply	M
3.Solid Waste *(Quantity of solid waste removed)*	**NC**: Fields, forests, sea and rivers not polluted by sludge	**S**: Reduced odour, visual impact, and health issues affecting nearby people	M
	PC: Removal of organic sludge avoids down-time, increasing cycles & yields	**B**: Increased profits and economic security among small-holder farmers	M
4. Resource Substitution *(Amount of fish meal or soybean meal protein replaced / kg of fish feed produced)*	**NC**: Reduced pressure on fisheries, reduced deforestation.	**S**: Healthier ecosystems, increased biodiversity, more fish for food/land for other crops	M
	PC: Local supply of protein ingredient used in animal feed recipe	**B:** Reduced costs of production ($/ton) for aquatic/animal feed products	M
		B/S: Reduced carbon emissions as less far for inputs to travel	M
5. Energy Use/GHGs *(Energy use per hour / Kg product produced)*	**NC**: Reduced carbon emissions; reduced demand on hydroelectric power	**B:** Reduced energy costs	M
		S: Reduced carbon emissions & global warming	M

In addition to the impact pathway mapping, the results of the high-level valuation, with their grounding in academic literature as well as the professional judgement by the consultant, can help to strengthen Biovert's 'proof of concept' business case.

It is important to note that these results are only indicative and remain preliminary. The high-level assessment is still ongoing and further desk-based research to collect evidence from a large pool of research studies could be conducted to validate the results. Moreover, the primary data collected through the detailed assessment will enable a more accurate and robust valuation of the company's potential impacts.

Despite the above, the high-level assessment results are useful because they indicate that the Biovert innovation has a positive impact across all four capitals. When presented to impact investors and at the TEEB-Agri conference in August, these results will assist Biovert in making an even stronger pitch that their innovation is not only an opportunity to improve the livelihoods of small-scale aquaculture farmers in the region, but one that adds social and ecological value in a region facing intense pressures from the proliferation of hydropower dams and the changing global climate.