SAVi Sustainable Asset Valuation

Sustainable Asset Valuation of the Kalivaç and Poçem Hydropower Projects

Assessing the environmental, social and economic impacts of energy pathways in Albania

SUMMARY OF RESULTS

IISD International Institute for Sustainable Development

MAVA Fondation pour la Nature

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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.

Website:
mava-foundation.org

A Sustainable Asset Valuation of the Kalivaç and Poçem Hydropower Projects — Assessing the environmental and economic impacts of energy pathway development in Albania

June 2020

Written by Laurin Wuennenberg, Andrea M. Bassi, Oshani Perera, David Uzsoki, Georg Pallaske, and Qendresa Rugova

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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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Abbreviations

BAU	business as usual
CAPEX	capital expenditure
CBA	cost–benefit analysis
CERs	carbon reduction emissions
CF	cash flow
CLD	causal loop diagram
EIA	environmental impact assessment
ESIA	environmental and social impact assessment
GDP	gross domestic product
HPP	hydropower plant
IRENA	International Renewable Energy Agency
IRR	internal rate of return
LCOE	levelized cost of electricity
MW	megawatt
MWh	megawatt hours
NGO	non-governmental organization
NPV	net present value
O&M	operation and maintenance
OPEX	operation and maintenance expenditure
SAVi	sustainable asset valuation tool
SD	system dynamics
SCC	social costs of carbon
WACC	weighted average cost of capital

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.

Discounting: A finance process to determine the present value of a future cash value.

Externality: An externality is a negative or positive impact, often referred to as a cost or benefit, that affects a third party who did not play a role in determining such impact. The third party, who can be private (individual, organization) or the society as a whole, did not choose to incur the cost or to receive the benefit. Hence, an externality is not reflected in the market price of a good or service (Kenton, 2019).

Econometrics: A methodology that measures the relation between two or more variables, running statistical analysis of historical data and finding correlation between specific selected variables.

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 (UNEP, 2014).

Internal rate of return (IRR): An indicator of the profitability prospects of a potential investment. The IRR is the discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero. Cash flows net of financing give us the equity IRR.

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 structure and equations are accessible and make it possible 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).

Net present value (NPV): The difference between the present value of cash inflows net of financing costs and the present value of cash outflows. It is used to analyze the profitability of a projected investment or project.

Risk: A risk in the context of infrastructure finance refers to the chance that a factor outside the direct control of an asset owner or operator materializes as a cost for an asset. The materiality of a risk is considered in relation to the asset under assessment. Risks can be of social, environmental (physical), economic, or regulatory origin. An externality caused by the same asset under assessment may or may not turn into a risk.

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).

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).

Social costs of carbon: The economic cost caused by an additional ton of carbon dioxide emission or its equivalent through the carbon cycle (Nordhaus, 2017).

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" (United Nations Environment Programme [UNEP], 2014, p. 51)

System dynamics (SD): A methodology developed by 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).

1.0 Introduction and Key Insights of the SAVi Assessment

Given the broad interest and increasing concerns voiced by environmental organizations and affected communities about hydropower development in Albania, it is crucial to assess and demonstrate if the environmental and socioeconomic development impacts of hydroelectric energy generation enable or hamper the delivery of value for money for taxpayers in Albania. Many hydropower projects are procured and stipulated under concession agreements, implying that they are handed over to the Albanian government at the end of the concession period. This raises the question of how the government intends to balance the benefits and adverse impacts of hydropower projects, and whether these plants will actually be able to operate at full capacity at the time of handover, given that medium- to long-term climate change impacts and other environmental risks may materialize over time.

The Sustainable Asset Valuation (SAVi) assessment of the hydropower projects (HPPs) Poçem and Kalivaç was undertaken in collaboration with the MAVA Foundation to investigate and calculate the costs of environmental and social externalities caused by these two projects currently being developed on the Vjosa River. It also sought to calculate how these projects perform if climate change risks materialize. By presenting the SAVi results in this report, we intend to inform the public debate on the environmental and societal costs of hydropower and shed light on economic concerns of HPP performance, while also addressing the economic performance of alternative energy generation pathways using solar photovoltaic (PV) and onshore wind technologies.

The SAVi methodology quantifies and values the environmental, social, and economic externalities of infrastructure projects as well as financial performance implications caused by environmental, social, economic and governance risks faced by the same projects. The methodology can also be applied to conduct comparative assessments between alternative infrastructure solutions. More information on the SAVi methodology may be found in Appendix A and on this website: https://iisd.org/savi/.

SAVi was customized and applied for assessing the two interrelated HPPs at Poçem and Kalivaç currently being developed on the Vjosa River. Concession agreements for both projects were signed, and they are being developed under a build-operate-transfer (BOT) model through partnerships with private investors. In this SAVi assessment, asset performance of the two HPPs is compared to the performance of a hypothetical solar PV system and a hypothetical onshore wind farm, assuming the provision of the same annual electricity generation by all three energy technologies. Section 2 provides a brief background about electricity generation in Albania, with a particular focus on hydropower. Section 3 introduces the various parameters considered in this SAVi assessment and refers to key data sources and assumptions. The entire set of data used and additional assumptions made are presented in Appendix A. The methodology for the customized SAVi models, consisting of a system dynamics (SD) model and a project finance model for each of the three assets, is described in Appendix B.

The results of the SAVi assessment are presented in Sections 4 and 5. The results provide quantitative evidence on the economic, environmental, and social co-benefits and costs arising from the two HPPs and the alternative energy generation technologies. These co-benefits and external costs (externalities) were valued and integrated into a cost–benefit analysis (CBA), presented in Section 4.1, and the calculation of the levelized cost of energy (LCOE), presented in Section 4.2, to demonstrate the societal value of these hydropower assets for Albania compared to the alternative technologies. Moreover, a climate change scenario was integrated into the assessment, using data sourced from the Copernicus Climate Data Store on future projections for precipitation rates in the area of the Vjosa catchment. Precipitation data were integrated into the SAVi model to calculate how they affect costs, externalities, and revenues of the two HPPs. These CBA and LCOE results are presented in subsections 4.1.3 and 4.2.3, respectively.

Finally, the SAVi assessment entails a financial analysis of the two HPPs, the solar PV system, and the onshore wind farm. This financial analysis integrates the monetary value of the above-mentioned externalities and climate change impacts. The results of different internalization scenarios and the effects of varying electricity price assumptions on the financial performance of the three assets are presented in Section 5.

The report closes with Section 6, which presents the multiple adverse impacts that HPPs Poçem and Kalivaç are anticipated to have on biodiversity and ecosystem services along the Vjosa River. The chapter also points to methods and a demonstration of how lost and degraded biodiversity and ecosystem services could be valued in order to be included in an integrated assessment approach like SAVi.

Table 1 summarizes key insights of this SAVi assessment for various stakeholder groups affected by or concerned with the construction and operation of the two HPPs as well as the alternative energy generating assets in Albania.

Table 1. Key insights of the SAVi assessment for different stakeholders

How can stakeholders use this analysis?

Stakeholder	Insight	Example
Politicians and Policy-makers	The valuation of externalities demonstrates to decision-makers that the hydro assets Poçem and Kalivaç imply considerable trade-offs. These emerge because the construction and operation of both HPPs have adverse effects on communities, economic sectors (such as agriculture and tourism), and ecosystems along the Vjosa River. The assessment results suggest that the two HPPs cannot be considered a preferable solution to generate electricity for the Albanian people. When comparing the total costs and benefits, the HPPs produce higher costs, societal burdens, and tax losses than benefits.	• The results of the cost-benefit analysis (CBA) prove that both HPPs are uneconomic—they imply higher costs than benefits. Negative performance is driven mainly by relatively high CAPEX and OPEX, high costs of dredging, and the high societal costs (externalities). The final analysis result of HPP Poçem amounts to negative EUR 233 million, and the final result of HPP Kalivaç to negative EUR 321 million. These results would further deteriorate if a lower discount rate is applied for calculating the net present value of the societal costs caused over the lifetime of each asset.
	The assessment results suggest that solar PV is a more beneficial and viable alternative for generating a comparable amount of electricity in Albania. Location-specific externalities of solar PV still need to be assessed once viable locations are identified. The current technology costs for onshore wind make it an unviable alternative in a price-competitive electricity market environment.	• Even though the CBA results of both solar PV and onshore wind are negative, these assets perform comparatively better than the HPPs. The final result of solar PV amounts to negative EUR 75.6 million, which is approximately 7.3 times less negative compared to the final CBA results of both HPPs. If comparing the integrated LCOE, which includes the financial value of externalities, the LCOE of the two HPPs is more than 2.5 times higher than the LCOE of solar PV and 1.5 times higher than the LCOE of onshore wind. • The financial analysis results highlight positive project IRR results for all three energy-generating assets while remaining below the assumed hurdle rate. Given the set of assumptions established for the analysis, these results place into doubt the financial feasibility of these assets. The project IRR for the hydro assets turns negative once the location-specific externalities are accounted for. This poor performance highlights the fact that the HPPs cannot be considered worthwhile investments from a societal point of view.

How can stakeholders use this analysis?

Stakeholder	Insight	Example
Politicians and Policy-makers	The cost-benefit analysis for the two HPPs also allows politicians and policy-makers to realize that substantial tourism potential will be lost along the Vjosa River if construction and operation of the HPPs move ahead.	• The lost tourism potential is economically approximated by estimating several tourism-related externalities. Over the lifetime of both HPPs, this amounts to more than EUR 10 million. If lower discount rates are applied (6.75% instead of 13.5%), this rises to more than EUR 22.5 million.
Public budget holders	The cost-benefit analysis and the calculated levelized cost of electricity allow public budget holders to comprehend the magnitude of tax revenue losses and societal costs caused over the lifetime of both HPPs. The calculated operational expenditures and the cost of dredging occurring after the concession period allow public budget holders to realize that the HPP assets are not free of costs once they are transferred to the government.	• Due to the inundation of agriculture lands and the resulting reduction of agriculture production, foregone tax revenues are the second highest negative externality caused by the two HPPs. The tax revenue losses amount to more than EUR 26 million over the lifetime of both assets and are higher than the additional tax revenues expected from corporate taxes to be paid by electricity producers. • The same conclusions can be drawn from assessing the LCOE of both HPPs. Under conventional calculations, the cost per MWh of electricity would be between EUR 121 (HPP Poçem) and almost EUR 158 (HPP Kalivaç). When integrating societal cost into the LCOE calculation, the cost per MWh of electricity would increase to EUR 184 and EUR 203, respectively.
Affected communities in proximity to the HPPs	The results of the cost-benefit analysis allow affected communities to see the magnitude of damage and foregone income that they have to bear due to the construction and operation of the two HPPs.	• The reservoirs of the two HPPs cause by far the highest negative externalities, as these cause inundations of land formerly used for agriculture. As such, agriculture activities can no longer take place in the impounded area over the entire lifetime of the hydro assets. This accumulates to a total foregone value of EUR 174 million. This will also reduce income from agriculture production, resulting in foregone discretionary spending of EUR 3.9 million. The value of these enduring negative externalities further increases to EUR 365 million and EUR 8.4 million, respectively, if a lower discount rate is applied for calculating their net present value (6.75% instead of 13.5%).

How can stakeholders use this analysis?

Stakeholder	Insight	Example
Concessionaires/ electricity producers	The SAVi assessment informs plant operators that regular sediment dredging of the hydro reservoirs—necessary to keep the HPPs operational at full capacity—implies high additional costs. These need to be considered when estimating the profitability of the HPPs. The results of the financial analysis suggest that supplying electricity to the domestic market in Albania alone will not be sufficient to make the HPPs financially attractive because of a market environment that promises relatively low electricity offtake prices. The LCOE results (as well as the results of the financial analysis) suggest that solar PV is the best-performing asset, given the current levels of capital costs. It is the only renewable energy technology that promises attractive returns when supplying the domestic market alone.	• The operational expenditures for the HPPs rise significantly if costs of dredging are considered: this is particularly true for HPP Kalivaç as its reservoir is the first in the Vjosa River course. The CBA, despite assuming a high discount rate of 13.5%, indicates dredging costs during the concession period of almost EUR 18.5 million for HPP Poçem and more than EUR 140.3 million for HPP Kalivaç. When assessing the conventional LCOE results of HPP Kalivaç, the costs of dredging account for more than 40% of the costs. • Given the relatively high CAPEX and OPEX for HPPs and the anticipated high cost of financing in Albania, a domestic electricity price of EUR 55 per MWh would not generate sufficient revenues—indicated by a Project IRR for both HPPs of 9.32% in a conventional scenario, which is below the required hurdle rate of 13.5%. If the concessionaires have to bear the anticipated cost for sediment dredging, the Project IRR further decreases. These results suggest that concessionaires will have to sell electricity to export markets where higher electricity prices can be obtained.

How can stakeholders use this analysis?

Stakeholder	Insight	Example
Environmental NGOs and CSOs	The calculated costs and lost values caused by the two HPPs provide tangible evidence to NGOs and CSOs of the magnitude of ecological and societal burdens. Tourism potential is lost due to the destruction of the pristine ecological conditions of the Vjosa River, communities living in proximity to the HPPs will bear the economic costs of foregone agriculture production, and societal costs are caused by GHG emissions generated in the hydro reservoirs. The assessment results demonstrate that NGOs and CSOs have valid and economically justifiable reasons for opposing the construction of the two HPPs. The assessment also sheds light on the impact of climate change on the performance of both HPPs by incorporating the projected reduction in precipitation. In total, the adverse impact on the performance results of both HPPs appears rather insignificant. Note on climate change parameters: Due to a lack of data during the assessment, several parameters—such as extreme weather events, effects of seasonality on precipitation levels, and effects of climate change on vegetation cover and erosion—were not considered. Future research should integrate such climate change-related parameters into a CBA and financial assessment once relevant	• By internalizing the environmental, social and economic externalities caused by the HPPs, the SAVi assessment approximates the true societal value of the HPPs. These results are considerably less favourable compared to conventional assessment results that ignore adverse impacts on communities and ecosystems. For example, the accumulated CBA results of both HPPs rise from negative EUR 340 million to negative EUR 554 million if externalities are accounted for, so rise the LCOE from EUR 141 per MWh to more than EUR 194 per MWh. • The economic value from lost tourism potential (≈ EUR 10 million) is described above, as are the costs for affected communities (≈ EUR 174 million). The societal costs of the GHG emissions caused by both HPPs over their asset lifetime amount to negative EUR 1.9 million. These negative values rise if lower discount rates are applied. • If the impacts of climate change are taken into account, the integrated LCOEs of the HPPs rise slightly. The integrated LCOE of HPP Poçem rise from EUR 183.80 per MWh to EUR 186.19 per MWh, while the integrated LCOE of HPP Kalivaç increases slightly from EUR 203.10 per MWh to EUR 203.50 per MWh.

How can stakeholders use this analysis?

Stakeholder	Insight	Example
Albanian Administrative Court	The assessment results allow the Albanian Administrative Court to comprehend the far-reaching implications if the two HPPs are constructed and operated. The assessment results provide grounds for better determining whether the HPPs are, in fact, bringing value to the Albanian people. As noted above, the magnitude of the trade-offs casts doubt on this. The SAVi assessment results also highlight to the Albanian Administrative Court that the HPPs perform poorly across the board (CBA, LCOE, and financial analysis results) given the assumption that all electricity is sold domestically at an offtake price of EUR 55 per MWh. As the HPPs do not generate attractive returns under this market condition (even if externalities are not accounted for), it is inevitable that the concessionaires will either sell significant volumes of electricity to export markets or will receive subsidized electricity prices in Albania. The financial analysis results show that, depending on the magnitude of the cost for sediment dredging, the average electricity price to be obtained in order to achieve a project IRR of 13.5% (hurdle rate) and an NPV of at least zero ranges between EUR 78.47 per MWh and EUR 108.39 per MWh. This strongly suggests that the HPPs are not only—or perhaps not even primarily—built to supply electricity to Albania, while the Albanian people need to bear the location-specific externalities that the HPPs cause along the Vjosa River.	• See the examples provided above for other stakeholder groups.

2.0 The Context of Hydropower Generation in Albania

Electricity generation in Albania is predominantly based on hydropower, with 88% of its power being sourced from a combination of three state-owned large HPPs on the river Drin as well as several HPPs owned and operated through private concessions (IRENA et al., 2017). Overreliance on hydro generation exposes the energy system to annual variations in precipitation levels. The country thus often experiences supply shortages in the summer months: these shortages are covered by imports. Security of supply and diversification through the promotion of renewable energy sources are highlighted as key objectives in Albania's national energy strategy 2018–2030.

Albania has significant potential for developing renewable energy sources—especially solar power—given its favourable geographical location and Mediterranean climate. IRENA estimates that an additional 4 gigawatts (GW) of cost-competitive renewable sources can be deployed in Albania, of which 1.9 GW are solar PV and over 1 GW are wind (IRENA et al., 2017). Despite this vast potential, Albania has not yet managed to unlock its renewable energy targets, with an installed capacity of 15 MW solar PV (OSHEE, 2019). Albania has recently revised its renewable energy targets as indicated by Albania's National Renewable Energy Actional Plan, which lays out the plan to add an additional 790 MW of renewable capacity, of which 600 MW are additional hydro capacity, 120 MW are solar PV, and 70 MW are wind energy (Ministry of Infrastructure and Energy (Albania), 2018).

Two new large-scale HPPs at Kalivaç and Poçem are expected to add a combined hydro capacity of more than 210 MW. They are being developed along the Vjosa River in Albania, one of the last intact river systems in Europe. Both projects are being developed under a build-operate-transfer (BOT) model through partnerships with private investors, which aim to increase the installed capacity in the country as well as ensure security of supply. HPP Kalivaç was originally granted to an Italian investor in 1997 who began some initial construction work in 2001. The continuation of construction was postponed several times until it fully stopped in 2007. The concession was later terminated by the government, and, shortly thereafter, the Ministry of Energy and Industry opened the project for tendering, ultimately granting the concession to a joint venture between Ayen Enerji and Fusha on June 6th, 2018. The entity of this joint venture is registered as a special purpose vehicle for the concession of Kalivaç under the name AYEN-ALB.

The concession for HPP Poçem was signed in 2017. However, following the agreement, the project was met with fierce opposition from environmental activists which ended up with a legal case being brought against the developers and the Government of Albania on the grounds that the environmental impact assessment (EIA) document had significant shortcomings, and the public consultation process was deficient. In May 2017, the Albanian Administrative Court in Tirana ruled against the construction of HPP Poçem. Both the developers and the government are currently appealing the decision.

Both HPPs encountered severe opposition from affected communities, environmental non-governmental organizations (NGOs), and several institutions of the European Union. The opposing parties are worried about the socioeconomic implications for communities that will be directly affected by the inundated landscapes for establishing the hydropower reservoir as well as further downstream impacts on freshwater supply. Moreover, the environmental NGOs, in particular, are voicing strong concerns about the devastating impacts the two HPPs are anticipated to cause on local biodiversity and ecosystems. Until today, the Vjosa River flows almost 260 km entirely free, untamed, and without major human disturbances from the Pindus mountains in Greece, through Albania into the Adriatic Sea. Most of the tributaries are similarly free-flowing and untouched. The beautiful landscapes along the river are characterized by seasonal changes, diverse riverbed shapes and widths, meandering river stretches, canyons, islands, and extensive wetlands that provide unique and diverse habitats for many aquatic and terrestrial species, including various endemic and endangered species (Hauer et al., 2019; Schiemer et al., 2018). The uniqueness of these ecosystems, the different services they provide to humans, and the promising ecotourism potential that these river landscapes possess are seen as endangered if the two HPPs are built. Figure 1 shows the river course of the Vjosa River (dark blue), extensive wetlands (orange), protected landscapes (green) and the sites of HPPs Kalivaç and Poçem.

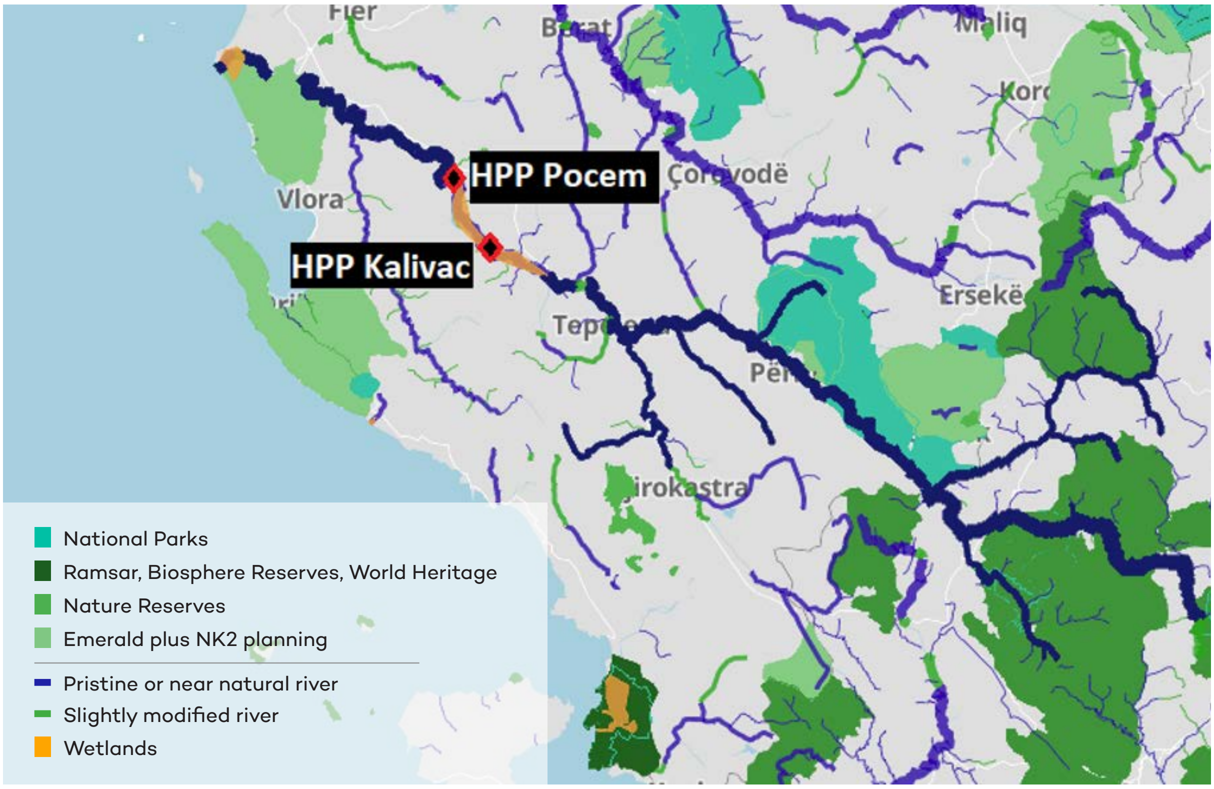

Figure 1. Vjosa River (dark blue) and sites of the two HPPs, protected areas, and wetlands.

3.0 Assessment Parameters, Data Sources, and Assumptions

The SAVi assessment includes the calculation and valuation of cost positions, revenue streams, externalities, and cost/revenue implications due to climate change impacts (reduced precipitation rates) for three energy generation technologies: hydropower, onshore wind, and solar PV. This section provides brief explanations of each considered parameter to ease the reading of results presented in several tables in Section 4. Quantitative information per technology, data sources, assumptions, and respective references are presented in detail in Appendix A.

The SAVi assessment includes the following conventional cost positions, externalities, and revenue streams for the assessed energy generation assets. Items (1) to (16) listed below are also indicated in the CBA and LCOE tables to make it easy to find the definitions presented in this section.

Cost Positions

1. **Capital cost:** Includes all expenditure (such as cost of planning, technical equipment, road construction, logistics, labour) for installing the energy generation capacity.
2. **Operation and maintenance (O&M) cost:** Includes all conventional expenditure (such as cost for technical equipment, logistics, and labour) required for operating and maintaining the energy asset. In the CBA (Chapter 4.1), operation and maintenance expenditure (Opex) is split into two components, reflecting different time periods when it arises: this is not for the calculation of LCOE (Chapter 4.2):

   (2.1) **O&M cost:** For the two HPP, this cost position refers to Opex during the concession period. For the solar PV system and the onshore wind farm, this refers to Opex during their 25-year lifetime.

   (2.2) **O&M cost after concession:** Refers to Opex for the two HPPs after the concession until the end of the lifetime. This cost position is not applicable for the solar PV system and the onshore wind farm.

3. **Concession payments:** These payments apply to the net income from electricity generation. The regular fee, expressed in percentage, applies to total revenues generated by the HPPs, regardless of their profitability. Concession payments do not apply to onshore wind and solar PV, as these energy assets are commonly financed and fully owned by private parties.
4. **Corporate tax rate for electricity producers:** 15% corporate tax is paid annually on the net profit of each energy asset.
5. **Cost of financing:** Includes interest rate payments and financing fees charged by financing institutions that provide debt and capital for different phases of the asset.

6. **Compensation payments:** Refers to the compensation to be paid by the HPP concessionaires to owners of agriculture land and owners of properties, including built structures, that will be inundated and destroyed as a consequence of establishing the hydropower reservoirs.
7. **Cost of dredging (during concession period):** A high volume of sediment is carried by the Vjosa River. According to a recent study, at least 3 million tons of sediment is transported to the coast per year (Hauer, et al., 2019). If reservoirs and dams are constructed for HPPs Kalivaç and Poçem, sediment transport is not only disrupted but will cause high volumes of sediments to settle in the reservoir. Although primarily in the first reservoir of HPP Kalivaç, the opening of gates for electricity generation will also transport a portion of the sediments to the Poçem reservoir. To maintain both HPPs in an operational state over time, regular dredging of sediment will be necessary.

   Dredging refers to the process of removing sediment from the bottom of the reservoir without removing the water beforehand. Dredging costs depend on the size of the reservoir, the amount of sediment to be regularly dredged, and the dredging technology applied. Dredging large reservoirs is often not considered economical, especially in river environments known for high sediment transport. However, dredging is the only solution for recovering water storage for planned electricity generation (International Hydropower Association, 2019). The costs for dredging and disposal of sediments for the HPPs Kalivaç and Poçem are estimated per year, building on the research conducted by Hauer et al. (2019). During the 35-year concession period, costs associated with dredging are considered an operational cost for the concessionaire and are not included in the conventional operating expenditure listed above. After the concession, dredging will have to be continued to keep the HPPs operational. Corresponding costs until the end of the assets' lifetime are considered an externality in this assessment (see item (16)).

Technology-Specific Externalities

The SAVi assessment quantifies and values in monetary terms the externalities that are associated with setting up and operating the energy asset, irrespective of the chosen location of the asset

8. **Discretionary spending from employment for energy capacity:** This refers to the amount of additional discretionary spending that flows into the Albanian economy from generated income by employing people for constructing and operating the energy asset. Discretionary spending describes expenses for non-essential consumer goods and services. The estimated additional spending by people employed for the construction and operation of the energy asset, compared to spending opportunities for unemployed people, is considered a benefit (positive externality) of the asset. It needs to be noted that this assessment does not differentiate between whether the employment generation and respective spending occurs in local communities or the country more broadly.

9. **Discretionary spending from employment for road construction**: This refers to the amount of additional discretionary spending that flows into the Albanian economy from generated income by employing people for constructing and maintaining the roads necessary for building and operating the energy asset. The explanations above also apply here.

   One addition is relevant for HPP Kalivaç: Since establishing the HPP's reservoir causes the flooding and destruction of a section of the Levan-Tepelena national road (item 10), a replacement road section needs to be built. The same discretionary spending effects apply for generated employment due to the construction of this national road section. Aside from the consideration that the flooding and destruction of a road section is a negative externality caused by the HPP Kalivaç (item 10), the employment and income spending effects caused by the newly constructed road section are considered a positive externality.

Location-Specific Externalities

The SAVi assessment quantifies and values in monetary terms the externalities that are associated with locational factors of the energy asset. In this assessment, such externalities are calculated only for the HPPs because the location for the HPP Kalivaç and HPP Poçem are determined. All externalities, except items (10) and (11), are calculated for the entire lifetime of both assets, which amounts to 60 years. Some externalities will likely remain beyond the lifetime of both assets, but this is not accounted for in this assessment. The location of the solar PV system and the onshore wind farm, which are hypothetical alternatives, are not determined for this assessment. The location-specific externalities defined below are hence not applicable for these two alternatives, which is indicated by "n/a" in the CBA and LCOE tables.

10. **Cost of new road section:** Setting up the Kalivaç reservoir will cause the inundation and destruction of local and national roads. In particular, a section of the Levan-Tepelena national road with an approximate length of 2.8 kilometres will be flooded (Abkons, 2019a). Some smaller roads that connect local villages will also be flooded. The section of the national road will need to be reconstructed at a higher altitude. The length of this new road section and related material and labour costs are estimated.
11. **Cost of dredging (after concession):** To maintain both HPPs operational after the concession period and continue electricity generation until the end of their lifetime (year 2058 to end of year 2082), dredging will have to be continued. Since both assets are scheduled to be handed over to the government after the concession period, the dredging cost will have to be borne by the government and hence society. The continued need for reservoir dredging is caused by the natural characteristics of the Vjosa River, and associated costs will be borne by society between year 36 and year 60. The dredging costs after the concession period are thus considered a location-specific externality.
12. **Reservoir-related net greenhouse gas (GHG) emissions from reservoir:** Dam construction and reservoir setup for hydropower generation along the Vjosa will cause large areas to be inundated, some of which were previously agricultural land and forest land. Biological decomposition processes in reservoirs result in methane and carbon

emissions (GHG emissions with varying global warming potential). Since the current natural vegetation (prior to impoundment) also causes carbon emissions, the net greenhouse gas emissions are estimated for the reservoir of HPPs Kalivaç and Poçem. It is assumed that the land is cleared prior to impoundment in order to keep the GHG emissions as low as possible over time.

13. **Impeded agriculture production:** Valued by estimating the foregone value added from agriculture, the foregone tax revenues from agriculture, and the foregone discretionary spending due to reduced employment.

    (13.1) **Foregone value added from agriculture:** The inundation of the agriculture land means that agriculture production can no longer take place there. To value the land use cost for hydropower production, an opportunity cost approach was applied. The foregone value creation per hectare of agriculture land was estimated for the particular inundated area in Albania.

    (13.2) **Foregone tax revenues from agriculture:** The foregone profit in the agriculture sector implies foregone tax revenues for the public sector in Albania. These opportunity costs are estimated over time by multiplying the annual foregone value added by the corporate tax rate in Albania.

    (13.3) **Foregone discretionary spending from lost agriculture employment:** This position indicates the foregone discretionary income spending of people who would have been employed in the agriculture sector.

14. **Foregone tourism potential:** The tourism sector in Albania has recently been growing, and the Vjosa River is recognized as an ecotourism destination with promising potential for increasing tourism numbers and associated income opportunities for Albanian enterprises, as evidenced by the plan to establish a Wild River National Park along the Vjosa River (Save the Blue Heart of Europe, 2019). However, there is reported evidence from other countries as well as location-specific studies about the adverse impact of the two HPPs on water flow, water level, hydrological regimes, natural habitats, biodiversity, and coastal landscapes (see Section 6). The construction of the two HPPs is hence recognized as a severe threat for the tourism potential in that region of Albania. It is hence assumed that tourism development will not occur if the HPPs are built. The foregone tourism potential is valued by applying an opportunity cost approach. The following three opportunity cost positions are estimated over the lifetime of the hydropower assets:

    (14.1) **Foregone value added from tourism:** Refers to the foregone value added from the tourism sector over time due to lost business activity in the tourism sector and lost tourism spending in Albania.

    (14.2) **Foregone tax revenues from tourism:** The foregone tourism business activities and foregone tourism spending implies less corporate tax and less value-added tax revenues for the public sector. Both are estimated over time.

    (14.3) **Foregone discretionary spending from tourism employment:** This position indicates the foregone discretionary income spending of people who would have been employed in the tourism sector.

Revenue Streams

15. **Electricity sales:** Revenues of the asset based on generated electricity sold over the lifetime of the asset. Electricity price assumptions refer to the offtake electricity price (EUR/MWh) that the producer receives in Albania (without adding further taxes and fees). The assumed electricity price is listed in Table 1 and further explained in Table 23 in Appendix A. The CBA in Section 4.1 distinguishes between electricity sales during and after the concession period:
    (15.1) Electricity sales during concession
    (15.2) Electricity sales after concession
16. **Carbon credits from avoided grid emissions:** Renewable energy projects developed in eligible geographies (Annex B List Kyoto Protocol) may receive additional benefits through the Clean Development Mechanism, which allows project owners to generate Carbon Reduction Emissions (CERs) that could be traded in emission trading schemes. Given that Albania qualifies for such mechanisms, it is reasonable to assume that the developers would seek to generate such additional revenue through CERs. The CBA in Section 4.1 distinguishes between revenues from carbon credits during and after the concession period:
    (16.1) Carbon credits during concession: These are additional revenues for the concessionaire.
    (16.2) Carbon credits after concession: These are additional revenues for the government once the HPPs are handed over from the concessionaire.

Table 2 summarizes the key technical assumptions used per assessed asset and the offset electricity price applied for electricity generated and sold across all assets.

Table 2. Technical assumptions for the energy assets

Factor	Unit	Hydropower		Solar PV	Onshore Wind
		HPP Poçem	HPP Kalivaç		
Installed capacity	MW	99.6	111.0	435.9	264.5
Construction time	Years	2	2	2	2
Operation time	Years	60	60	25	25
Electricity generation (annual)	MWh/Year	305,400	366,600	672,000	672,000
Assumed load factor	%	35.0	37.7	17.6	29.0
Price of electricity	EUR/MWh	55			

Figure 2 shows a generalized systems diagram presenting the systemic approach that this SAVi assessment uses to estimate 1) the societal contribution of electricity generation from hydropower, solar PV, and onshore wind, and 2) how elements of the system affect the infrastructure assets under assessment. The diagram shows how the asset is embedded in the system (energy, in this case) and how it affects a variety of social, economic, and environmental indicators. The system dynamics and project finance models used for this SAVi assessment (described in more detail in Appendix B) include indicators of capacity and generation, employment, and fuel consumption. Thus, conventional cost positions (revenues as well as negative and positive externalities caused by the assets) are estimated: see definitions for all estimated elements above in this Section 3.

Externalities affect a third party in the system that did not play a role in determining such effects of the energy generating assets. Externalities are displayed on the right side in the systems diagram in Figure 2. Finally, climate change impacts that will likely materialize as costs or reduced revenues for an energy asset are estimated. The climate-related variable considered for the assessment of climate change impacts on electricity generation capacity in this SAVi assessment is precipitation (affects water availability in the Vjosa River). Future variations of precipitation are externally defined and affect the load factor and efficiency of hydropower-based electricity generation, which in turn affect generation costs and revenues.

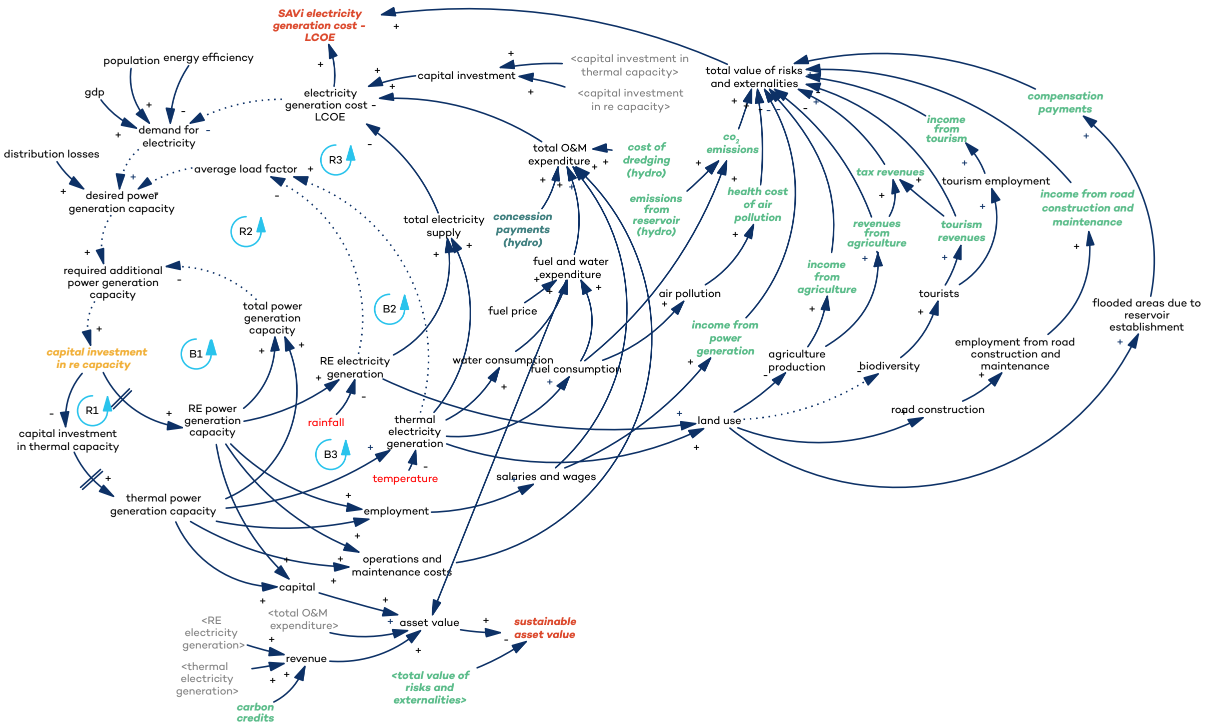

Figure 2. Conceptual representation in a causal loop diagram of the systemic analysis performed with (i) a system dynamics and (ii) a project finance model.

Legend: Red variables represent exogenous climate-related assumptions; green variables represent externalities; orange variables are investment decisions (e.g., investment in a specific asset). The diagram shows that circular causal relations between variables form causal feedback loops. Causal loop diagrams include variables and arrows (called causal links), with the latter linking the variables together with a sign (either + or −) on each link, indicating a positive or negative causal relation (see Table B1 in Appendix B). Positive causal links are reinforcing relations that amplify change over time, while negative links imply balancing effects that reduce change over time and lead to equilibriums.

4.0 SAVi Results — Integrated Cost–Benefit Analysis and Integrated Levelized Cost of Electricity

This section presents the results of the integrated CBA and the LCOE for the three assessed energy assets: the two HPPs, the solar PV system, and the onshore wind farm. The calculations of the CBA results and the LCOE are based on system dynamics modelling and consider the entire life cycle of each asset, though some lifetime variations are presented for the HPPs only and are indicated accordingly.

Cost assumptions for the HPPs stem from the concession agreements while assumptions for the cost of technology for the solar PV system are based on a technical report by the Fraunhofer Institute for Solar Energy Systems ISE (2018) and for the onshore wind farm recent technology cost figures published by IRENA (2019) were used. Assumptions for the technical characteristics and capital requirements of the solar PV system and the onshore wind farm are adjusted, so that each of the two installed technologies could generate the same annual amount of electricity as the two HPPs combined, which amounts to approximately 672 GWh per year. This allows for a more appropriate comparison between the three technologies as done in the CBA below. However, there are two important aspects concerning comparability. First, the lifetime of the HPPs is assumed to be 60 years—more than twice as long as the assumed 25-year lifetime of the solar PV system and onshore wind farm. Second, the assessed energy generation technologies commonly serve different purposes in a national energy system and hence cannot be considered completely replaceable alternatives: While solar PV and onshore wind are known to be intermittent electricity generators, hydropower often serves for baseload electricity generation. However, comparing these two energy assets to hydropower is considered reasonable given that Albania's energy mix is dominated by hydropower, and the national energy strategy puts an emphasis on the need to diversify energy supply by way of supporting other renewable energies such as wind and solar PV. This was demonstrated by the recently increased targets defined in the National Renewable Energy Actional Plan as well as the two recent government tenders for a combined 200 MW of solar PV through a competitive auction system (Ministry of Infrastructure and Energy (Albania), 2018).

4.1. Results of the Integrated Cost–Benefit Analysis

This section presents the results of the calculated CBA. First, the HPPs Poçem and Kalivaç are compared to the solar PV system and onshore wind farm. For this purpose, environmental, social, and economic externalities caused by the three assets are integrated into the comparative CBA. Second, the effects of applying different discount rates for calculating the net present value (NPV) of externalities caused by the HPPs are presented. Third, the impacts of climate change parameters on costs, externalities, and revenues of the two HPPs are highlighted.

4.1.1. Results of the Comparative CBA: HPPs, solar PV, and onshore wind

The CBA in Table 3 presents the results of the evaluation of the three assets. Results for the HPP Poçem and HPP Kalivaç are presented both separately and together (column 2). The CBA integrates the monetary values of the economic, environmental, and social externalities resulting from the assets. The assessment distinguishes between technology- and location-specific externalities. The technology-specific externalities are characteristic for the respective asset and are caused irrespective of where the asset is set up. The location-specific externalities are caused by the asset but depend on where it is set up and operates over time. The location-specific externalities are estimated only for the HPPs in this assessment since the locations for the alternative solar PV system or the onshore wind farm are not yet determined.

Because onshore wind and solar PV should not be considered 100% replaceable alternatives for hydropower, only a one-time investment into solar PV and onshore wind was assumed, which would allow for a 25-year lifetime. A potential additional investment to replace the end-of-life of the two energy technologies after 25 years was not considered for calculating the results of the CBA. The lifetime of the two HPPs is 60 years. Costs and externalities that are not applicable for the solar PV system or the onshore wind farm are indicated in respective cells with “n/a.” All conventional cost positions, externalities, and revenues that occur over time are discounted by 13.5% to calculate the NPV of each asset.

There are four positions in Table 3, applicable to the HPPs, that occur as costs or benefits during and after the concession period: O&M cost, cost of dredging, electricity sales, and carbon credits. If they occur after the concession period, “after concession” appears in brackets. The “after concession” costs and benefits positions (2.2), (11), (15.2) and (16.2) are not borne by the concessionaire but by the government or society more broadly. The same holds true for all listed externalities. All other conventional cost positions aside from (2.2) are borne by the respective concessionaire during the 35-year concession period. The solar PV system and onshore wind farm are assumed to be implemented by private operators and not as concessions. The values indicated for corporate taxes (4) and cost of financing (5) in the CBA are calculated based on the SAVi financial model—a financial model for each asset was built. The financing assumptions for each asset and the results of the financial models are presented in Section 5.

Table 3. **Integrated CBA (in EUR million), comparing the two HPPs Poçem and Kalivaç to solar PV and onshore wind. Discount rate: 13.5%**

Cost and benefit categories (EUR million)	**HPPs (both)**	**HPP Poçem**	**HPP Kalivaç**	**Solar PV**	**Onshore wind**
Costs					
(1) Capital cost	(243.25)	(120.70)	(122.56)	(192.02)	(304.67)
(2.1) O&M cost	(36.62)	(18.17)	(18.45)	(25.41)	(55.61)
(2.2) O&M cost (after concession)	(0.45)	(0.22)	(0.23)	n/a	n/a
(3) Concession payments	(4.80)	(2.13)	(2.67)	n/a	n/a
(4) Corporate taxes	(7.06)	(3.21)	(3.85)	(9.85)	(0.61)
(5) Cost of financing	(113.26)	(51.47)	(61.79)	(82.99)	(137.00)
(6) Compensation payments	(7.98)	(3.99)	(3.99)	n/a	n/a
(7) Cost of dredging	(158.78)	(18.45)	(140.32)	n/a	n/a
Subtotal (A)	**(572.20)**	**(218.34)**	**(353.86)**	**(310.26)**	**(497.88)**
Externalities					
Externalities (technology-specific)					
(8) Discretionary spending: employment energy capacity	4.97	2.35	2.62	12.65	6.05
(9) Discretionary spending: employment roads	2.45	0.09	2.36	0.13	0.01
Subtotal (B): Value of technology specific externalities	**7.41**	**2.44**	**4.97**	**12.78**	**6.06**
Externalities (location-specific)					
(10) Cost of new road section	(2.15)	0.00	(2.15)	n/a	n/a
(11) Cost of dredging (after concession)	(2.92)	(0.34)	(2.58)	n/a	n/a
(12) Reservoir-related GHGs	(1.89)	(1.12)	(0.76)	n/a	n/a
(13.1) Foregone value added: agriculture	(174.00)	(98.93)	(75.06)	n/a	n/a
(13.2) Foregone tax revenues: agriculture	(26.10)	(14.84)	(11.26)	n/a	n/a
(13.3) Foregone discretionary spending: agriculture employment	(3.91)	(2.22)	(1.69)	n/a	n/a

Cost and benefit categories (EUR million)	**HPPs (both)**	**HPP Poçem**	**HPP Kalivaç**	**Solar PV**	**Onshore wind**
(14.1) Foregone value added: tourism	(7.82)	(3.91)	(3.91)	n/a	n/a
(14.2) Foregone tax revenues: tourism	(1.77)	(0.88)	(0.88)	n/a	n/a
(14.3) Foregone discretionary spending: tourism employment	(0.78)	(0.39)	(0.39)	n/a	n/a
Subtotal (C): Value of location-specific externalities	**(221.34)**	**(122.64)**	**(98.70)**	**0.00**	**0.00**
Subtotal (D): Total value of externalities	**(213.93)**	**(120.21)**	**(93.72)**	**12.78**	**6.06**
Subtotal (E): Total cost + externalities	**(786.13)**	**(338.55)**	**(447.58)**	**(297.48)**	**(491.82)**
Revenues					
(15.1) Electricity sales	222.80	101.25	121.55	215.49	215.49
(15.2) Electricity sales (after concession)	2.75	1.25	1.50	n/a	n/a
(16.1) Carbon credits	6.69	3.04	3.65	6.39	6.39
(16.2) Carbon credits (after concession)	0.08	0.04	0.04	n/a	n/a
Subtotal (F): Total revenues	**232.33**	**105.58**	**126.75**	**221.89**	**221.89**
Net results					
Net results (conventional)	**(339.88)**	**(112.77)**	**(227.11)**	**(88.37)**	**(275.99)**
SAVi Net results (including externalities)	**(553.81)**	**(232.97)**	**(320.83)**	**(75.59)**	**(269.93)**

One needs to recall that the annual electricity generation of the two HPPs combined is as large as the annual electricity generation by each of the other two assets. Hence, the combined HPPs' results need to be compared to solar PV and onshore wind. Subtotal (A) captures only the conventional cost positions of each asset. The results highlight that the two HPPs combined are the most expensive asset, followed by the onshore wind farm and the solar PV system—the latter being the cheapest by far. While the capital and O&M costs of the two HPPs lie between the corresponding costs for solar PV and onshore wind, a significant cost position applies only for the HPPs: cost of dredging. This cost item is explained in Section 3. Costs of dredging are much higher for the HPP Kalivaç compared to the HPP Poçem because the former is the first HPP in the river course, and so sediments arrive in the respective reservoir, while only a fraction of this sediment is channelled to the reservoir of HPP Poçem. This is why less dredging needs to happen in the Poçem reservoir.

The technology-specific externalities considered in this assessment are positive for all three assets, they refer to additional discretionary spending from income generated by employment for building and operating the energy assets as well as building and maintaining the necessary road infrastructure. The discretionary spending from the solar PV system amounts to almost EUR 13 million over the 25-year lifetime and is hence more than double the discretionary spending from the onshore wind farm. The respective results for the HPPs lie in between, amounting to almost EUR 5 million for the HPP Kalivaç (due to additional road-related employment caused by rebuilding a flooded national road section—see explanations for item (9) in Section 3) and only EUR 2.4 million for HPP Poçem.

As explained above, location-specific externalities estimated in this assessment apply only for the HPPs. They are defined and explained in detail in Section 3 and in Appendix A. By far the highest negative externalities are caused by the reservoirs of the two HPPs, as these cause inundations of land formerly used for agriculture. As such, agriculture activities will no longer take place in the impounded area over the entire lifetime of the hydro assets, accumulating to foregone value added of EUR 174 million. Accordingly, foregone tax revenues for the government are the second highest negative externality caused by the two HPPs, amounting to more than EUR 26 million.

If the monetary value of the economic, environmental, and social externalities is added on top of the conventional costs, the total (Subtotal E) for the HPPs combined amounts to more than EUR 786 million, while the total cost for the solar PV and wind capacity amounts to only approximately EUR 297 million and EUR 492 million respectively. It is important to note that location-specific externalities were not calculated for the latter two assets. Some negative externalities related to land use, property price effects, and ecosystem interference are also to be expected by setting up and operating either the solar PV system or the onshore wind farm. This would need to be assessed and valued when a siting for these assets is being considered.

All three energy assets generate revenues over time due to selling electricity and selling carbon credits. Subtotal (F) indicates the total revenues for each asset, which are very similar between the three assets. The two HPPs combined generate only approximately EUR 10 million more than the solar PV system or the onshore wind farm despite the fact that the lifetime and hence revenue-generating time of the HPPs is more than double that of the other two assets. This rather small absolute difference is primarily caused by the high discount rate of 13.5% that heavily reduces the NPV of revenues generated in the far future.

Both net results (the conventional one and the SAVi net result) are negative for all assets. The solar PV system achieves the fewest negative net results, irrespective of whether or not externalities are accounted for. The negative net results are high for the two HPPs, in particular when considering the SAVi net result. This sum also integrates the total monetary value of the economic, environmental, and social externalities caused by each respective hydro asset. The SAVi net result for HPP Poçem amounts to a negative value of almost EUR 233 million, and the corresponding SAVi net result for the HPP Kalivaç is negative EUR 321 million, yielding a combined negative net result of almost EUR 554 million.

4.1.2. CBA Results of the HPPs: The effect of different discount rates

In this section, the effects of applying different discount rates for calculating the NPV of externalities caused by the two HPPs are presented. Table 4 compares the results of the HPPs presented in Section 4.1.1 with results when assuming a reduced discount rate of 6.75% for calculating the NPV of the various technology- and location-specific externalities caused by the HPPs. Results with the low discount rate assumptions are presented in the columns with a light blue background colour. The reduced discount rates serve to put a stronger emphasis on externalities that occur in the future and make them weigh more in the CBA calculations. Presenting this additional perspective on discount rates when assessing the HPPs is important due to two aspects:

First, HPPs are long-lived assets, and their negative impacts on agriculture production, tourism potential, and ecosystems continue over time. Today's decision making should take into account the long-lasting adverse and irrevocable effects for future generations. This only appears feasible if future social and environmental costs do not appear insignificant. This can be achieved by assuming lower discount rates or discount rates that decline over time. There are debates about this in science and policy-making, including discounting issues when conducting CBAs, and good reasons are presented why future social and environmental costs should be discounted at low or declining rates compared to discounting conventional financial or economic values, see for example Martinez-Paz et al., (2016) and Organisation for Economic Co-operation and Development (OECD) (2018).

Second, HPP Poçem and HPP Kalivaç are both planned to be built and operated under a 35-year concession agreement, at the end of which both assets are expected to be handed over to the Albanian government. Therefore, it appears crucial to demonstrate to the Albanian government and the society more broadly what external costs and benefits these projects still produce after the 35-year concession period. Applying lower discount rates to externalities that are often insufficiently considered in regular CBAs makes it possible to put a stronger emphasis on the future value of these externalities occurring after the concession period.

Table 4. Integrated CBA for the HPPs (in EUR million), comparing the effects of the base case with a reduced discount rate case: 13.5% for conventional cost positions and revenues; 6.75% applied to externalities only.

	HPPs (both)		HPP Poçem		HPP Kalivaç	
Cost and benefit categories (EUR million)	**Base case**	**Reduced discount rate**	**Base case**	**Reduced discount rate**	**Base case**	**Reduced discount rate**
Conventional cost positions						
(1) Capital cost	(243.25)	(243.25)	(120.70)	(120.70)	(122.56)	**(122.56)**
(2.1) O&M cost	(36.62)	(36.62)	(18.17)	(18.17)	(18.45)	**(18.45)**
(2.2) O&M cost (after concession)	(0.45)	(0.45)	(0.22)	(0.22)	(0.23)	**(0.23)**
(3) Concession payments	(4.80)	(4.80)	(2.13)	(2.13)	(2.67)	**(2.67)**
(4) Corporate taxes	(7.06)	(7.06)	(3.21)	(3.21)	(3.85)	**(3.85)**
(5) Cost of financing	(113.26)	(113.26)	(51.47)	(51.47)	(61.79)	**(61.79)**
(6) Compensation payments	(7.98)	(7.98)	(3.99)	(3.99)	(3.99)	**(3.99)**
(7) Cost of dredging	(158.78)	(158.78)	(18.45)	(18.45)	(140.32)	(140.32)
Subtotal (A)	**(572.20)**	**(572.20)**	**(218.34)**	**(218.34)**	**(353.86)**	**(353.86)**
Externalities						
Externalities (technology-specific)						
(8) Discretionary spending: employment energy capacity	4.97	5.59	2.35	2.64	2.62	2.95
(9) Discretionary spending: employment roads	2.45	2.98	0.09	0.14	2.36	2.83
Subtotal (B): Value of technology specific externalities	**7.41**	**8.56**	**2.44**	**2.79**	**4.97**	**5.78**
Externalities (location-specific)						
(10) Cost of new road section	(2.15)	(2.51)	0.00	0.00	(2.15)	(2.51)
(11) Cost of dredging (after concession)	(2.92)	(44.93)	(0.34)	(5.22)	(2.58)	(39.71)
(12) Reservoir-related GHG	(1.89)	(3.97)	(1.12)	(2.36)	(0.76)	(1.61)

Cost and benefit categories (EUR million)	HPPs (both)		HPP Poçem		HPP Kalivaç	
	Base case	Reduced discount rate	Base case	Reduced discount rate	Base case	Reduced discount rate
(13.1) Foregone value added: agriculture	(174.00)	(364.53)	(98.93)	(207.27)	(75.06)	(157.26)
(13.2) Foregone tax revenues: agriculture	(26.10)	(54.68)	(14.84)	(31.09)	(11.26)	(23.59)
(13.3) Foregone discretionary spending: agriculture employment	(3.91)	(8.41)	(2.22)	(4.78)	(1.69)	(3.63)
(14.1) Foregone value added: tourism	(7.82)	(17.61)	(3.91)	(8.81)	(3.91)	(8.81)
(14.2) Foregone tax revenues: tourism	(1.77)	(3.20)	(0.88)	(1.60)	(0.88)	(1.60)
(14.3) Foregone discretionary spending: tourism employment	(0.78)	(1.76)	(0.39)	(0.88)	(0.39)	(0.88)
Subtotal (C): Value of location-specific externalities	**(221.34)**	**(501.62)**	**(122.64)**	**(262.02)**	**(98.70)**	**(239.60)**
Subtotal (D): Total value of externalities	**(213.93)**	**(493.05)**	**(120.21)**	**(259.23)**	**(93.72)**	**(233.82)**
Subtotal (E): Total cost + externalities	**(786.13)**	**(1,065.25)**	**(338.55)**	**(477.58)**	**(447.58)**	**(587.68)**
Revenues						
(15.1) Electricity sales	222.80	222.80	101.25	101.25	121.55	**121.55**
(15.2) Electricity sales (after concession)	2.75	2.75	1.25	1.25	1.50	**1.50**
(16.1) Carbon credits	6.69	6.69	3.04	3.04	3.65	**3.65**
(16.2) Carbon credits (after concession)	0.08	0.08	0.04	0.04	0.04	**0.04**
Subtotal (F): Total revenues	**232.33**	**232.33**	**105.58**	**105.58**	**126.75**	**126.75**
Net results						
Net results (conventional)	**(339.88)**	**(339.88)**	**(112.77)**	**(112.77)**	**(227.11)**	**(227.11)**
SAVi Net results (including externalities)	**(553.81)**	**(832.93)**	**(232.97)**	**(372.00)**	**(320.83)**	**(460.93)**

The effects of applying a 50% lower discount rate on externalities caused by the HPPs are apparent when comparing the discrepancies between conventional net results and the SAVi net results. For the HPP Poçem, the SAVi net results are approximately EUR 120 million more negative than the conventional net results if a 13.5% discount rate applies for all factors in the CBA. If the reduced discount rate of 6.75% is applied to externalities caused by Poçem, the discrepancy between the conventional net results and the SAVi net results increases significantly. In that case, the SAVi net results are almost EUR 260 million more negative. Expressed differently, if comparing the SAVi net results for HPP Poçem between discounting used in the base case and reduced discounting applied to externalities in the reduced scenario, the latter case yields SAVi net results that are almost EUR 140 million more negative, i.e., negative EUR 327 million instead of negative EUR 233 million. For HPP Kalivaç, the discrepancy is similarly significant.

The largest absolute contribution to these discrepancies is caused by the increasing value of externalities (11), (13.1) and (13.2). The latter two—the foregone value added and the foregone tax revenues due to impeded agriculture production—were already significant when applying the 13.5% discount rate but increase much more when discounting these only by 6.75%. Externality (11) refers to the cost of dredging after the concession agreement. Dredging of sediments in the reservoirs remains necessary to keep the HPPs operational and enable electricity generation over time. After the concession period, the cost of dredging will have to be covered by the government, i.e. be funded by taxpayers. Since this cost occurs only between years 36 and 60, assuming a 13.5% discount rate has a large discounting effect on these future costs and causes dredging for this entire period to amount to less than EUR 3 million—almost insignificant compared to other cost positions. If the discount rate assumption is changed to 6.75%, the cost of dredging for both HPPs after the concession period rises to almost EUR 45 million, and hence appears more relevant for decision making.

Consequently, if a government is taking long-term investment and procurement decisions for public infrastructure projects, it is worthwhile to test various sets of discount rates on cost and benefit factors to better understand the magnitude of benefits and burdens the project at hand implies over time for its citizens and taxpayers.

4.1.3. CBA Results of the Two HPPs: The impacts of climate change

This section explores the impact of climate change parameters on the performance results of the HPPs. Energy generation infrastructure based on renewable energy sources, such as hydropower, strongly depends on ecological processes such as the functioning of the hydrological cycle. Climate change is expected to have significant impacts on such ecological processes over time.

Data Sources

For this SAVi assessment, regional as well as location-specific precipitation data and projections for the Vjosa catchment area were sourced from the Copernicus Climate Data Store.[1] For both, historical data (from 2000) and future projections (until 2100) were analyzed. The historical data are sourced from the ERA5 database and comprise mean monthly precipitation data, and the forecasts use CMIP5 data on mean monthly precipitation flux (more specifically, median projections were used) (Copernicus Climate Change Service (C3S), 2017). For these projections, results were obtained from an ensemble of nine climate models running scenario rcp_8_5. The results are bias-corrected for each month of the year.

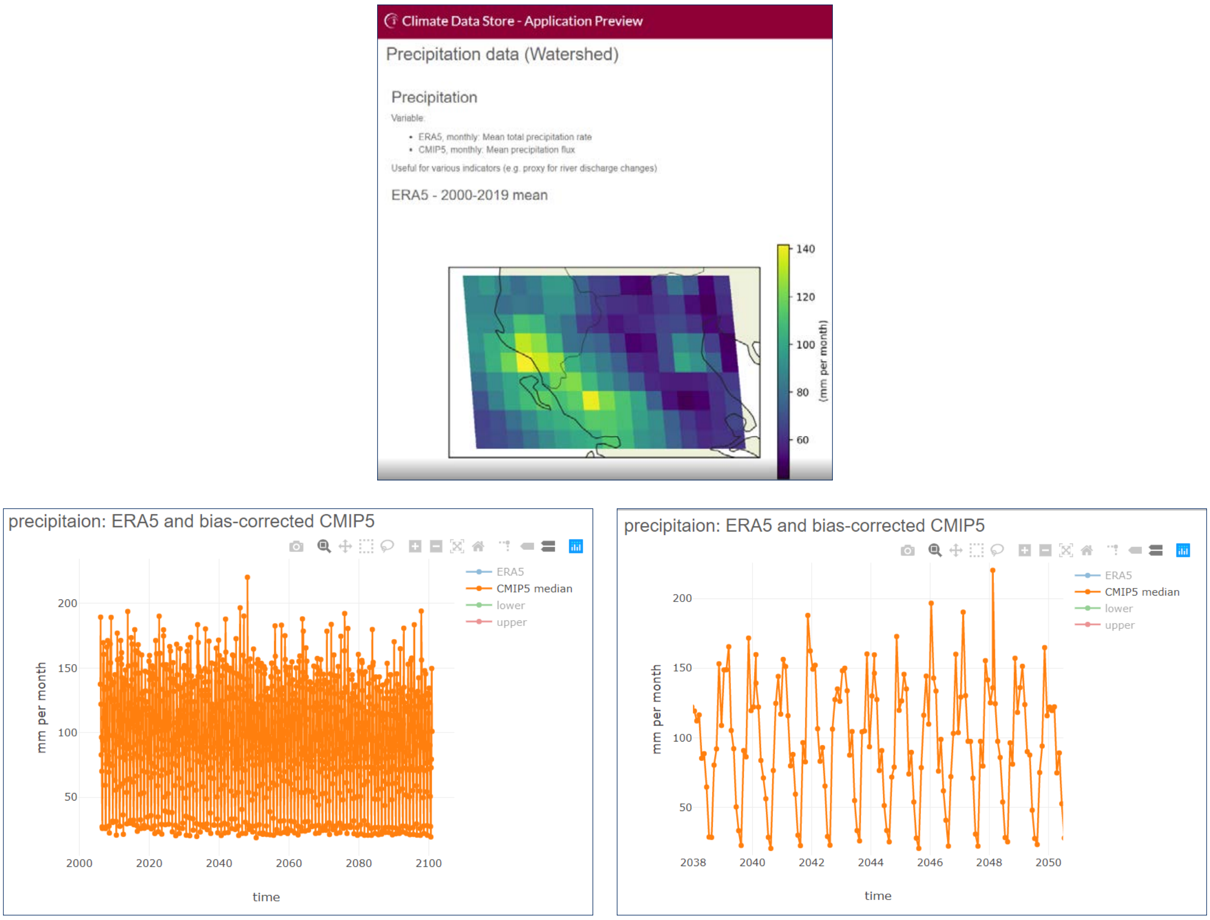

Figure 3. Illustrations of precipitations data sourced from the Copernicus Climate Data Store

[1] The calculated climate change impacts in this SAVi assessment build on modified Copernicus Climate Change Service Information (2020). Neither the European Commission nor the European Centre for Medium-Range Weather Forecasts is responsible for any use that may be made of the Copernicus information or data it contains.

Projected Precipitation Changes and Method for Integrating Climate Change Impacts into SAVI

The results of both regional and local forecasts are consistent and show a projected decline of precipitation. This is on average 20 mm less per month by 2100 relative to 2000 precipitation levels, with the decline larger in the rainy season than in the dry season. In the system dynamics model, a linear decline in precipitation was hence assumed, starting from the year 2000, so as to reach an average reduction per month consistent with the projected average reduction of 20 mm less precipitation per month by 2100.

Two scenarios were designed for this SAVi assessment:

- **Business-as-usual (BAU) scenario:** Constant average precipitation rates based on historical data. This scenario was used for calculating results in Sections 4.1.1 and **4.1.2.**
- **Climate Change (CC) impacts scenario:** Future projections of precipitation were used as described above, assuming an average reduction of 20 mm less precipitation per month by 2100.

The precipitation parameters are proxies for river discharge changes of the Vjosa River. Precipitation rates and flux influence hydropower generation potential by affecting the volume of water in the river system and hence water volumes arriving in the hydropower reservoirs. If precipitation decreases, water volume in the river may decrease and adversely affect the ability of HPPs to operate at full capacity. Therefore, electricity generation potential may be reduced, which has implications for several cost and revenue positions.

The according results on affected conventional costs, externalities and revenues of the two HPPs are presented in Table 5. A regular discount rate of 13.5% is applied for all factors. The table presents the results under regular BAU conditions from Table 3, referred to as BAU in Table 5, and compares these to the results when climate change impacts are taken into account, referred to as Subtotal (B), (C) and (E). In total, a new SAVi net result is calculated for each HPP.

Table 5. Climate change impacts (reduction in precipitation) on costs, externalities, and revenues of HPP Poçem and HPP Kalivaç (in EUR million)

Cost and benefit categories (EUR million)	**HPPs (both)**	**HPP Poçem**	**HPP Kalivaç**
	Regular DC	**Regular DC**	**Regular DC**
Conventional cost positions			
Conventional cost (BAU scenario)	**(572.20)**	**(218.34)**	**(353.86)**
CC impacts with cost-reducing effects on:			
Concession payments	0.08	0.04	0.05
Corporate taxes	0.89	0.41	0.49
Cost of dredging	7.38	0.86	6.53

Cost and benefit categories (EUR million)	**HPPs (both)**	**HPP Poçem**	**HPP Kalivaç**
	Regular DC	**Regular DC**	**Regular DC**
Subtotal (A). Reducing effects of CC on total costs	**8.36**	**1.30**	**7.06**
Subtotal (B). Conventional cost, incl. CC impacts	**(563.84)**	**(217.04)**	**(346.80)**
Externalities			
Total value of externalities (BAU scenario)	**(213.93)**	**(120.21)**	**(93.72)**
Reducing effects of CC on cost of dredging (after concession)	0.23	0.03	0.21
Subtotal (C): Total value of externalities, incl. CC impacts	**(213.70)**	**(120.18)**	**(93.52)**
Revenues			
Total revenues (BAU scenario)	232.33	105.58	126.75
CC impacts on electricity sales	(3.89)	(1.77)	(2.12)
CC impacts on electricity sales (after concession)	(0.28)	(0.13)	(0.15)
CC impacts on carbon credits	(0.12)	(0.06)	(0.07)
CC impacts on carbon credits (after concession)	(0.01)	(0.004)	(0.005)
Subtotal (D): Reducing effects of CC on total revenues	**(4.30)**	**(1.95)**	**(2.35)**
Subtotal (E): Total revenues, incl. CC impacts	**228.03**	**103.63**	**124.40**
Net results			
Net results (conventional): BAU scenario	(339.88)	(112.77)	(227.11)
Net results (conventional): CC scenario	(335.81)	(113.42)	(222.40)
Δ (CC difference on conventional results)	**4.06**	**(0.65)**	**4.71**
SAVi Net results: BAU scenario	(553.81)	(232.97)	(320.83)
SAVi Net results: CC scenario	(549.51)	(233.59)	(315.91)
Δ (CC difference on SAVi net results)	**4.30**	**(0.62)**	**4.92**

The results in Table 5 demonstrate that assessed CC impacts have a lowering effect on costs, externalities, and revenues. The general explanation is simple. A reduction of precipitation rates compared to current precipitation rates is forecasted. This will reduce water availability in the Vjosa River and slightly reduce the electricity generation potential of the two HPPs. The plants won't be able to operate at full capacity over time. This is evidenced in Table 5 by the reduction in electricity sales. Electricity sales presented in Table 3 and Table 4 were based on the assumption that HPPs operate at full capacity and sell 100% of the generated electricity—these revenue results are repeated in Table 5 indicated by "BAU scenario." If climate change impacts are taken into account, electricity generation will be reduced and decreases revenues from electricity sales for HPP Poçem by EUR 1.77 million and for HPP Kalivaç by EUR 2.12 million during the concession period. After the concession period, revenues from electricity sales for HPP Poçem will be reduced by EUR 0.13 million and for HPP Kalivaç by EUR 0.15 million. It needs to be noted that a discount rate of 13.5% is applied to these revenue streams. If a lower discount rate would be assumed, future revenue losses due to climate change impacts will appear even larger. In accordance with these explanations, the revenues sourced through the selling of carbon credits will also be lower than in a BAU scenario. Consequently, Subtotal (E) shows the reduced total revenues when climate change impacts are taken into account.

In line with the reduction of electricity generation due to climate change impacts, concession payments and corporate tax payments will be lower compared to a BAU scenario that does not take climate change impacts into account. This is the case because both payments are linked to the profits of each project. If electricity sales are reduced, so are the profits and hence the concession and corporate taxes paid. Likewise, less precipitation and lower water volume and flow in the Vjosa River implies less sediment transport. This results in less dredging needed to keep the HPPs operational, which in particular reduces dredging costs for HPP Kalivaç—the first of the two reservoirs in the Vjosa River course. Altogether, total conventional costs for both HPPs are lower in Table 5 (Subtotal (B)) compared to the BAU scenario.

The only externality of this SAVi assessment that is directly affected by climate change impacts is the dredging cost after the concession period. Explanations for why these costs are reduced compared to a BAU scenario apply are highlighted in the previous paragraph.

The climate change impacts, i.e., the reduction in precipitation over time, affect both HPPs to different degrees. The SAVi net results for HPP Kalivaç are, in fact, improved (less negative) because of a significant reduction in dredging costs. The SAVi net results for HPP Poçem, on the other hand, are even more negative than under BAU conditions because the decreased revenues are higher than the cost savings caused by climate change impacts. Assessing the SAVi net results of both HPP cumulatively, shows an overall positive performance effect of assessed climate change impacts, increasing the SAVi net results by EUR 4.3 million and hence making them less negative.

The impacts of climate change are also considered in the financial analysis of this SAVi assessment, and the results indicate more significant—and indeed adverse—impacts on the financial performance of the two HPPs compared to results in the CBA. The financial performance results are presented in Section 5.

4.2. Results of the Integrated LCOE

In this section, the levelized cost of electricity generation (LCOE) of the three energy assets is presented. The environmental, social, and economic externalities caused by the HPPs, by the solar PV system and by the onshore wind farm are integrated into the respective LCOE calculations. In a second step, the climate change impacts on the LCOE of both HPPs are also presented.

LCOE is a measure of the unit cost of electricity generation. It provides a full breakdown of cost components. LCOE is a useful indicator for comparing the unit cost of different technologies over their lifetimes (IEA & NEA, 2015). It is calculated by dividing the net present costs of generation over the lifetime of capacity by the net present generation. In other words, it is calculated by dividing cumulative discounted costs (i.e., EUR) by cumulative discounted generation, typically indicated in MWh.

Similar to the integrated CBA discussed in Section 4.1, externalities are integrated (as cost and benefit items) into the calculation of the LCOE in all tables of this section. The calculation of the integrated LCOE is done for the three energy-generating assets to make the comparative analysis more comprehensive and disclose the "societal" cost of power generation by the respective asset type. Because the LCOE is a cost indicator, positive externalities are indicated with a minus sign (they reduce the LCOE) in the table below, whereas negative externalities are adding to the LCOE.

4.2.1. Results of the Comparative LCOE Calculations: HPPs, solar PV, and onshore wind

This section presents the LCOE results of the HPPs, the solar PV system, and the onshore wind farm when environmental, social, and economic externalities caused by the respective assets are accounted for. Results are presented in Table 6. A few explanatory remarks need to be noted for this table. The second column presents the weighted average results of both HPPs—compared to the CBA results, the individual HPP results are hence not simply added up, but a weighted average factor is applied that takes into account the varying energy generation capacity of the two HPPs. This is reasonable, as the LCOE does not present absolute monetary figures but figures per MWh. For the HPPs, the concession period (35 years) was used as a reference period. For the solar PV system and the onshore wind farm, the 25-year lifetime was used to calculate the LCOE results in Table 6. Since the LCOEs are calculated per MWh in relation to the total energy generated over a considered time period, the LCOE results of the two HPPs for a 60-year time period are similar to the results presented in Table 6. The LCOE results for the 60-year period are presented in Table C1 in Appendix C.

Table 6. Itemized LCOE (EUR/MWh) by technology, comparing concession period of HPPs with regular lifetime of solar PV and onshore wind; Discount rate 13.5%

LCOE categories (EUR/MWh)	HPPs (both), weighted average	HPP Poçem	HPP Kalivaç	Solar PV	Onshore wind
	35 years			25 years	
Conventional cost positions					
(1) Capital cost	60.05	65.56	55.45	49.01	77.76
(2) O&M cost*	9.04	9.87	8.35	6.49	14.19
(3) Concession payments	1.74	1.91	1.59	0.00	0.00
(4) Corporate taxes	1.68	1.51	1.82	2.54	0.16
(5) Cost of financing	28.28	30.88	25.83	21.38	35.29
(6) Compensation payments	1.18	1.15	1.21	0.00	0.00
(7) Cost of dredging*	39.19	10.02	63.49	0.00	0.00
Subtotal (A): Conventional LCOE	**141.16**	**120.91**	**157.74**	**79.41**	**127.39**
Externalities					
Externalities (technology-specific)					
(8) Discretionary spending: employment energy capacity	(1.22)	(1.27)	(1.18)	(3.23)	(1.54)
(9) Discretionary spending: employment roads	(0.10)	(0.05)	(0.14)	(0.03)	(0.00)
Subtotal (B): Value of technology-specific externalities	**(1.32)**	**(1.32)**	**(1.33)**	**(3.26)**	**(1.55)**
Externalities (location-specific)					
(10) Cost of new road section	3.08	0.00	5.65	0.00	0.00
(12) Reservoir-related GHG	0.46	0.60	0.34	0.00	0.00
(13.1) Foregone value added: agriculture	42.46	53.12	33.57	0.00	0.00
(13.2) Foregone tax revenues: agriculture	6.37	7.97	5.04	0.00	0.00
(13.3) Foregone discretionary spending: agriculture employment	0.95	1.19	0.75	0.00	0.00
(14.1) Foregone value added: tourism	0.98	0.98	0.98	0.00	0.00

LCOE categories (EUR/MWh)	HPPs (both), weighted average	HPP Poçem	HPP Kalivaç	Solar PV	Onshore wind
	35 years			25 years	
(14.2) Foregone tax revenues: tourism	0.25	0.25	0.25	0.00	0.00
(14.3) Foregone discretionary spending: tourism employment	0.10	0.10	0.10	0.00	0.00
(14.3) Foregone discretionary spending: tourism employment	(0.78)	(1.76)	(0.39)	(0.88)	(0.39)
Subtotal (C): Value of location specific externalities	**54.65**	**64.21**	**46.68**	**0.00**	**0.00**
Subtotal (D): Total value of externalities	**53.32**	**62.88**	**45.36**	**(3.26)**	**(1.55)**
SAVi LCOE (incl. externalities)	**194.48**	**183.80**	**203.10**	**76.14**	**125.85**

*Note: The LCOE table, in contrast to the CBA tables in Section 4.1, does not distinguish between costs and externalities that occur during and after the concession period for the two HPPs. The LCOE calculation does not account for differences in time when cost and externalities accrue. Cost position (2) captures all O&M costs and cost position (7) captures all costs of dredging over the considered time period. Externality position (11) is hence deliberately not listed in the LCOE table.

As the LCOE results are calculated per MWh generated, the results of each individual HPP can be compared to the other energy-generation assets. Subtotal (A) adds up all the conventional cost positions of each asset to calculate the respective conventional LCOE. The results highlight that HPP Kalivaç is the most expensive asset, while HPP Poçem is less expensive than the onshore wind farm. The fact that electricity generated by HPP Kalivaç is significantly more costly compared to HPP Poçem when considering each asset's conventional LCOE is primarily caused by the diverging costs for dredging. Explanations apply as presented in Section 4.1.1 and Section 3. Considering that the weighted average conventional LCOE results of the two HPPs are approximately EUR 141 per MWh, hydropower is the most expensive technology for generating electricity. The solar PV system accounts for the lowest conventional LCOE of slightly less than EUR 80 per MWh.

Subtotal (B) covers the LCOE results of the technology-specific externalities per asset. Solar PV yields the highest positive externalities—as noted above, positive figures are indicated in brackets in Table 6 because they reduce the LCOE. LCOE results for the technology-specific externalities of onshore wind are slightly higher than the results of the HPPs.

As explained in Section 4.1.1, location-specific externalities estimated in this assessment apply only for the HPPs. They are defined and explained in detail in Section 3. Likewise, explanations for the most significant externality values found in the LCOE table apply are provided in Section 4.1.1. Subtotal (C) accumulates the LCOE values of all location-specific externalities, which is higher for HPP Poçem than for HPP Kalivaç. Subtotal (D), on the other hand, adds up LCOE values of all externalities.

The final SAVi LCOE results integrate the externalities and conventional LCOE. The SAVi LCOE of the HPP Kalivaç is by far the highest, followed by the HPP Poçem, onshore wind, and solar PV. The SAVi LCOE results of both HPPs is more than 2.5 times the LCOE of solar PV, pointing to how costly electricity generated by hydropower is for Albanian society compared to generating electricity by solar PV. This is caused by the high cost of dredging necessary to operate HPPs in the Vjosa River as well as by the high location-specific externalities, especially the foregone value added from agriculture production caused by the two HPPs.

4.2.2. LCOE Results of the HPPs: The effect of different discount rates

This section presents the effects of applying different discount rates for calculating the LCOE of the two HPPs. Table 7 presents the results of the two HPPs when comparing the use of regular and reduced discount rates. The same was applied to the CBA calculations as presented in Section 4.1.2. Explanations of why the monetary value of several externalities is significantly higher when using a lower discount rate of 6.75% as opposed to 13.5% for discounting the monetary value of externalities apply accordingly. Consequently, the SAVi LCOE for the HPPs in Table 7 is much higher compared to the base case when future externalities are discounted less drastically, as shown by the results of columns titled with "Reduced Discount Rate." In that case, generating electricity from the two hydropower assets appears even less favourably for Albanian society compared to the results presented in Table 6 (results are repeated in left-hand columns in Table 7). As for calculating the LCOE in Table 6, the concession period of 35 years was used as the reference period.

In addition, Table C2 in Appendix C presents the same effects of applying different discount rates for valuing the externalities of both HPPs while considering a 60-year reference period for calculating the LCOE.

Table 7. Itemized LCOE (EUR/MWh) of the HPPs during the concession period (35 years), comparing the effects of the base case with a reduced discount rate case: 13.5% for conventional cost positions and revenues; 6.75% applied to externalities only.

	HPPs (both), weighted average		HPP Poçem		HPP Kalivaç	
LCOE Categories (EUR/MWh)	**Base case**	**Reduced discount rate**	**Base case**	**Reduced discount rate**	**Base case**	**Reduced discount rate**
Conventional cost positions						
(1) Capital cost	60.05	60.05	65.56	65.56	55.45	55.45
(2) O&M cost*	9.04	9.04	9.87	9.87	8.35	8.35
(3) Concession payments	1.74	1.74	1.91	1.91	1.59	1.59

LCOE Categories (EUR/MWh)	**HPPs (both), weighted average**		**HPP Poçem**		**HPP Kalivaç**	
	Base case	**Reduced discount rate**	**Base case**	**Reduced discount rate**	**Base case**	**Reduced discount rate**
(4) Corporate taxes	1.68	1.68	1.51	1.51	1.82	1.82
(5) Cost of financing	28.28	28.28	30.88	30.88	25.83	25.83
(6) Compensation payments	1.18	1.18	1.15	1.15	1.21	1.21
(7) Cost of dredging*	39.19	39.19	10.02	10.02	63.49	63.49
Subtotal (A): Conventional LCOE	**141.16**	**141.16**	**120.91**	**120.91**	**157.74**	**157.74**
Externalities						
Externalities (technology-specific)						
(8) Discretionary spending: employment energy capacity	(1.22)	(1.37)	(1.27)	(1.42)	(1.18)	(1.32)
(9) Discretionary spending: employment roads	(0.10)	(0.14)	(0.05)	(0.07)	(0.14)	(0.20)
Subtotal (B): Value of technology-specific externalities	**(1.32)**	**(1.51)**	**(1.32)**	**(1.50)**	**(1.33)**	**(1.52)**
Externalities (location-specific)						
(10) Cost of new road section	3.08	3.60	0.00	0.00	5.65	6.59
(12) Reservoir-related GHG	0.48	0.90	0.64	1.18	0.34	0.67
(13.1) Foregone value added: agriculture	42.46	82.43	53.12	103.13	33.57	65.18
(13.2) Foregone tax revenues: agriculture	6.37	12.36	7.97	15.47	5.04	9.78
(13.3) Foregone discretionary spending: agriculture employment	0.95	1.90	1.19	2.37	0.75	1.50
(14.1) Foregone value added: tourism	0.98	1.96	0.98	1.96	0.98	1.96
(14.2) Foregone tax revenues: tourism	0.25	0.50	0.25	0.50	0.25	0.50

LCOE Categories (EUR/MWh)	HPPs (both), weighted average		HPP Poçem		HPP Kalivaç	
	Base case	Reduced discount rate	Base case	Reduced discount rate	Base case	Reduced discount rate
(14.3) Foregone discretionary spending: tourism employment	0.10	0.20	0.10	0.20	0.10	0.20
Subtotal (C): Value of location-specific externalities	**54.65**	**103.83**	**64.21**	**124.80**	**46.68**	**86.37**
Subtotal (D): Total value of externalities	**53.32**	**102.33**	**62.88**	**123.30**	**45.36**	**84.85**
SAVi LCOE (incl. externalities)	**194.48**	**243.49**	**183.80**	**244.22**	**203.10**	**242.59**

*Note: The LCOE table, in contrast to the CBA tables in Section 4.1, does not distinguish between costs and externalities that occur during and after the concession period for the two HPPs. The LCOE calculation does not account for differences in time when cost and externalities accrue. Cost position (2) captures all O&M cost and cost position (7) captures all cost of dredging over the considered time period. Externality position (11) is hence deliberately not listed in the LCOE table.

4.2.3. Climate Change Impacts on the LCOE of Hydropower

This section presents the impacts of assessed climate change parameters on the LCOE of the two HPPs. Data sources and methods for integrating climate change into the SAVi model were described in Section 4.1.3. The following two scenarios were designed:

- **BAU scenario:** Constant average precipitation rates based on historical data. This scenario was used for calculating results in Section 4.1.1 and 4.1.2.
- **CC impacts scenario:** Future projections of precipitation were used as described above, assuming an average reduction of 20 mm less precipitation per month by 2100.

As presented in Section 4.1.3: If accounting for precipitation forecasts for the estimation of total electricity generation potential of both HPPs, a reduction of future electricity generation compared to a BAU scenario (without climate change impacts) is the consequence. This has two consequences for LCOE calculation. The cost and externality positions of each HPP are divided by a lower electricity amount compared to a BAU scenario because climate change impacts reduce the net present generation of electricity. Moreover, the reduced precipitation rates have implications for several cost positions as explained in Section 4.1.3: The reduction in electricity generation potential and reduction in electricity sales affect cost positions such as concession payments and corporate taxes. Moreover, lower precipitation—which leads to reduced water levels and river flow in the Vjosa River—causes less sediment transport and hence lower dredging costs.

These two consequences for calculating the LCOE of the HPPs imply that the results of almost all conventional cost and externality elements listed in Table 8 are different from the results of the BAU scenario. This can be observed when comparing the "BAU" and the "CC impacts" columns of each respective HPP. However, one can also observe that differences between these scenarios are marginal, resulting in the SAVi LCOE weighted average result for both HPPs of 194.48 EUR/MWh in the BAU scenario and 195.63 EUR/MWh in the climate change scenario. In anticipation of materializing climate change impacts, such as decreasing precipitation rates in the Vjosa catchment region, electricity generated by hydropower will become slightly more expensive on a per-MWh basis. On the other hand, the cost of dredging will decrease, resulting in SAVi LCOE results for the HPP Kalivaç being almost identical between the BAU scenario and the climate change scenario. Table 8 shows the LCOE results based on calculations taking the concession period as the reference timeframe. Table C1 in Appendix C presents LCOE results for the entire 60-year lifetime of the two HPPs.

Table 8. Climate change impacts (reduction in precipitation) during the concession period on the itemized LCOE of HPP Poçem and HPP Kalivaç (EUR/MWh)

	HPPs (both), weighted average		HPP Poçem		HPP Kalivaç	
LCOE Categories (EUR/MWh)	**BAU scenario**	**CC impacts scenario**	**BAU scenario**	**CC impacts scenario**	**BAU scenario**	**CC impacts scenario**
Conventional cost positions						
(1) Capital cost	60.05	61.11	65.56	66.73	55.45	56.44
(2) O&M cost*	9.04	9.20	9.87	10.04	8.35	8.50
(3) Concession payments	1.74	1.77	1.91	1.94	1.59	1.62
(4) Corporate taxes	1.68	1.56	1.51	1.40	1.82	1.68
(5) Cost of financing	28.28	28.59	30.88	31.21	25.83	26.40
(6) Compensation payments	1.18	1.18	1.15	1.15	1.21	1.21
(7) Cost of dredging*	39.19	38.03	10.02	9.73	63.49	61.61
Subtotal (A): Conventional LCOE	**141.16**	**141.44**	**120.91**	**122.21**	**157.74**	**157.46**

LCOE Categories (EUR/MWh)	HPPs (both), weighted average		HPP Poçem		HPP Kalivaç	
	BAU scenario	CC impacts scenario	BAU scenario	CC impacts scenario	BAU scenario	CC impacts scenario
Externalities						
Externalities (technology-specific)						
(8) Discretionary spending: employment energy capacity	(1.22)	(1.25)	(1.27)	(1.30)	(1.18)	(1.20)
(9) Discretionary spending: employment roads	(0.10)	(0.10)	(0.05)	(0.05)	(0.14)	(0.14)
Subtotal (B): Value of technology-specific externalities	**(1.32)**	**(1.35)**	**(1.32)**	**(1.35)**	**(1.33)**	**(1.35)**
Externalities (location-specific)						
(10) Cost of new road section	3.08	3.09	0.00	0.00	5.65	5.66
(12) Reservoir-related GHG	0.46	0.47	0.60	0.61	0.34	0.35
(13.1) Foregone value added: agriculture	42.46	43.21	53.12	54.06	33.57	34.17
(13.2) Foregone tax revenues: agriculture	6.37	6.48	7.97	8.11	5.04	5.13
(13.3) Foregone discretionary spending: agriculture employment	0.95	0.97	1.19	1.21	0.75	0.77
(14.1) Foregone value added: tourism	0.98	0.98	0.98	0.98	0.98	0.98
(14.2) Foregone tax revenues: tourism	0.25	0.25	0.25	0.25	0.25	0.25
(14.3) Foregone discretionary spending: tourism employment	0.10	0.10	0.10	0.10	0.10	0.10
Subtotal (C): Value of location-specific externalities	**54.65**	**55.54**	**64.21**	**65.32**	**46.68**	**47.39**
Subtotal (D): Total value of externalities	**53.32**	**54.19**	**62.88**	**63.98**	**45.36**	**46.04**
SAVi LCOE (incl. externalities)	**194.48**	**195.63**	**183.80**	**186.19**	**203.10**	**203.50**

5.0 SAVi Results of the Financial Analysis

This section presents the results of the financial analysis conducted for the two HPPs Poçem and Kalivaç as well as the financial performance results of the hypothetical solar PV system and the onshore wind farm. The financial analysis incorporates the implications of externalities and climate change impacts on the financial performance of assets, with a particular focus on the two HPPs Poçem and Kalivaç.

5.1. Scenarios, Internalization Methodology, and Assumptions

A financial model was built for each of the three energy generating assets considered in this SAVi assessment. These financial models calculate the financial performance of the respective asset and generate results for a range of financial performance indicators. Results of the following two financial performance indicators are presented in the next sections under different scenarios analyzed: the project NPV and the project IRR. The NPV is a performance indicator that is used to analyze the profitability of a projected investment or project. The NPV result demonstrates the difference between the present value of cash inflows net of financing costs and the present value of cash outflows. The IRR is an important financial performance indicator that investors use to evaluate infrastructure projects. It serves as an indicator of the profitability prospects of a potential investment. The IRR is the discount rate that makes the NPV of all cash flows from a particular project equal to zero.

The following scenarios have been assessed and corresponding results will be presented in this section while analyzing the effects of varying assumptions:

i) **Baseline:** Includes only the project-related costs, such as capital, operating expenditures, and cost of financing—these are the conventional cost positions (1) to (6) explained in Section 3. The baseline scenario also includes the two conventional revenue streams from electricity sales (15) and carbon credits (16).

ii) **Baseline + cost of dredging:** In addition to the conventional revenues and cost items, the costs of dredging, described as position (7) in Section 3, are included in the analysis—as explained in previous sections, this applies only for the two HPPs.

iii) **Baseline + technology-specific externalities:** In addition to the conventional revenues and cost items (but excluding the cost of dredging), this scenario considers the financial performance implications if the technology-specific externalities are internalized into the project finance model of each asset. These are described as positions (8) and (9) in Section 3.

iv) **Baseline + location-specific externalities:** In addition to the conventional revenues and cost items (but excluding cost of dredging), this scenario considers the financial performance implications if the location-specific externalities are internalized into the project finance model of the HPPs—these are described as positions (10) to (14) in Section 3. As explained in previous sections, such externalities are not assessed for the hypothetical assets.

v) **Baseline + all externalities:** In addition to the conventional revenues and cost items (but excluding cost of dredging), this scenario considers the financial performance implications if the technology-specific and the location-specific externalities are internalized into the project finance model of each asset.

The varying NPV and IRR results for all assets are presented under these five scenarios in Section 5.2. In addition, Section 5.3 presents how the HPPs perform under these five scenarios if projected physical climate change impacts on precipitation parameters, as introduced in Section 4.1.3, are incorporated into the project finance model. Finally, Section 5.4 presents how all assets perform if assumptions for electricity prices are changed.

The monetary value of externalities and climate change-related implications for the magnitude of costs and externalities can be internalized into the financial model of an energy generating asset in several ways. For this SAVi assessment, levelized values were calculated and internalized into the annual financial flows of the respective financial model. The levelized values for the financial analysis are calculated in a way similar to the calculation of the LCOE in Section 4.2 of this report. The total amount of undiscounted monetized externalities that emerge during the construction and operation of each asset is divided by the total electricity generation over the lifetime of each asset. The same is done for incorporating the impacts of climate change into the analysis of the HPPs. The assessed precipitation changes have implications for the magnitude of some costs and externalities as well as implications for the total electricity generation of HPP Poçem and HPP Kalivaç. In order to integrate the levelized value of externalities and climate change impacts on levelized costs and levelized externalities into the financial model, these levelized values are then multiplied by the electricity generation for each year assessed. Therefore, this approach takes all externalities and climate change-related cost factors into account that occur during an asset's lifetime. While their monetary values are allocated to each operating year of the asset relative to the electricity being generated, the methodology does not reflect the real magnitude of externalities and climate change-related cost factors per year. Appendix B provides more details about the methodology of the project finance model of SAVi.

Table 9 lists the various assumptions that have been defined for each asset in conducting the financial analysis. It needs to be noted that the HPPs are assessed as one investment project because their combined annual electricity generation is as high as the annual electricity generation of each of the two investment alternatives being the solar PV system and the onshore wind farm. Therefore, this section does not present individual results for HPP Poçem and HPP Kalivaç. Moreover, the entire 60-year lifetime of the combined HPPs is assumed in the financial analysis as compared to the 25-year lifetime of the other two assets. Given that the HPPs are deployed as BOT projects under the 35-year concession agreements, the financial model incorporates that all debt obligations are paid back within the concession period time. After 35 years, asset ownership will be transferred from the concessionaire and equity shareholders to the Albanian government. Regional conditions for financing energy infrastructure projects have been consulted (Fraunhofer ISI, 2016), and inferences were made to define reasonable assumptions for the debt-to-equity ratio and the weighted average cost of capital (WACC) for the three assets, including cost of debt and cost of equity. The WACC assumptions are at the higher end compared to European Union countries analyzed in the cited study, and debt-to-equity ratio is based on a relatively high equity share informed by observations in neighbouring countries of Albania.

Table 9. Key assumptions for the financial analysis

Assumptions	Unit	HPPs (Poçem & Kalivaç combined)	Solar PV	Onshore wind
Construction time	Years	2	2	2
Operation time	Years	60	25	25
Concession time	Years	35	n/a	n/a
Construction cost	EUR Million	276.79	217.94	359.76
Operation cost	EUR/MWh	9.04	6.49	14.17
Installed capacity	MW	210.6	435.9	264.5
Electricity generation	MWh p.a.	672,000	672,000	672,000
Capital split (debt to equity ratio)	%	50% / 50%	50% / 50%	50% / 50%
Discount rates	Project/WACC: % Cost of equity: %	Project: 13.5% Equity: 16.0%	Project: 13.5% Equity: 16.0%	Project: 13.5% Equity: 16.0%
Debt tenor	Years	30	20	20
Cost of debt (average)	%	13	13	13

5.2. Results of the Financial Analysis

5.2.1. NPV and IRR Results of Hydropower, Solar PV, and Onshore Wind

This section presents the NPV and IRR results of the conducted financial analysis for the combined HPPs, the solar PV system, and the onshore wind farm. Results are presented according to different scenarios analyzed and are based on the assumptions as introduced in Section 5.1.

Table 10 displays the project NPV results of the three assets under the five cost scenarios. It is important to note that none of the three energy generating assets can be considered financially attractive when assessing the NPV results. Under each cost scenario, the NPVs for all three assets are negative. This is primarily caused by the relatively low electricity price assumption of EUR 55 per MWh and the high cost of financing that energy-generating assets face due to the country, market, and technology risks. When comparing the three assets, the solar PV system yields the least negative project NPV amounting to negative EUR 16.3 million under the baseline scenario. The negative project NPV result of the HPPs is almost five times higher. If the cost of dredging to keep the HPPs operational at full capacity throughout their lifetime is also considered in the financial analysis, the project NPV amounts to more than negative

EUR 181 million and is hence more than 11 times more negative than the project NPV result of solar PV and also more negative than the project NPV result of the onshore wind farm. Neither of the latter two assets has to bear the cost of dredging, which is why "n/a" is indicated for the scenario (ii) in Table 10.

Scenarios (iii) to (v) are rather of analytical nature to present how the energy assets perform from a societal point of view. These scenarios demonstrate how the assets perform if project externalities are internalized and considered as having a cash-flow impact in the project finance model of each asset. In line with the CBA results and LCOE results presented in Section 4, the NPV result of each asset slightly improves if technology-specific externalities are internalized (scenario (iii)). These externalities are positive for all assets since each asset creates employment and additional income spending opportunities. Scenario (iv) applies only for the HPPs. As explained in detail in Sections 3 and 4, the HPPs cause a range of negative location-specific externalities. If the monetary values of these negative externalities are internalized into the project finance model of the HPPs, the NPV worsens to negative EUR 262 million. Scenario (v) presents the NPV results if the monetary values of technology-specific and location-specific externalities are internalized. Consequently, the NPV result for the HPPs improves slightly compared to scenario (iv), and the NPV results for the solar PV system and the onshore wind farm are as high as in scenario (iii).

Table 10. Project NPV for the three assets under different cost scenarios

Scenario	Project NPV HPPs (both)	Project NPV solar PV	Project NPV onshore wind
(i) Baseline: Conventional results	(79.85)	(16.30)	(158.30)
(ii) Baseline + cost of dredging	(181.62)	n/a	n/a
(iii) Baseline + technology-specific externalities	(79.04)	(12.88)	(156.19)
(iv) Baseline + location-specific externalities	(262.16)	n/a	n/a
(v) Baseline + all externalities	(261.20)	(12.88)	(156.19)

Table 11 presents the project IRR results of the three assets under the five cost scenarios. In the baseline scenario (i), the three assets yield a positive project IRR. In line with the NPV results, the solar PV system performs the best, followed by the HPPs and the onshore wind farm. The project IRR of the solar PV system and the onshore wind farm do not change much under the different scenarios. The positive project IRR results attest that all three energy generating assets are financially viable. However, none of the three assets yields an IRR that sufficiently reflects the expected return of investors for such energy projects in Albania. As introduced in Section 5.1, the WACC is 13.5%. This percentage should be considered as the minimum project IRR result for achieving a satisfying risk–return profile. The solar PV system gets closest to this threshold value.

Explanations for IRR changes between scenarios (ii), (iii), (iv) and (v) apply as explained for Table 10. The project IRR of the HPPs decreases by more than 6 percentage points if the costs of dredging are considered. If the monetary values of location-specific externalities are internalized (scenario (iv)), the project IRR of the HPPs becomes negative. This remains the same in scenario (v). From a societal point of view, the internalization of monetary values of externalities into the calculation of the project IRR represents a social rate of return on investments. The negative project IRR in scenarios (iv) and (v) therefore suggests that the HPPs cannot be considered worthwhile from a societal point of view.

Table 11. Project IRR for the three assets under different cost scenarios

Scenario	Project IRR HPPs (both)	Project IRR Solar PV	Project IRR Onshore Wind
(i) Baseline: Conventional results	9.32%	12.23%	5.09%
(ii) Baseline + cost of dredging	3.15%	n/a	n/a
(iii) Baseline + technology-specific externalities	9.36%	12.50%	5.22%
(iv) Baseline + location-specific externalities	**negative**	n/a	n/a
(v) Baseline + all externalities	**negative**	12.50%	5.22%

5.2.2. Climate Change Impacts on the Financial Performance of HPP Poçem and Kalivaç

This section highlights the project NPV and the project IRR results of the HPPs when climate change-related parameters are considered in the assessment. Future projections of precipitation were studied for the Vjosa catchment and corresponding effects on the HPPs were calculated as presented in Section 4.1.3. Table 12 presents the project NPV and the project IRR results under the following two scenarios:

- **BAU scenario:** Constant average precipitation rates based on historical data. This scenario was used for calculating results in Section 5.2. These results are repeated in Table 12.
- **CC impacts scenario:** Future projections of precipitation were used as described in Section 4.1.3, assuming an average reduction of 20 mm less precipitation per month by 2100.

All results in Table 12 highlight that the financial performance of the HPPs gets poorer once climate change impacts are considered in the assessment. However, the insights of Section 5.2 are not significantly affected. Altogether, performance results of scenario (i) and scenario (ii) highlight that the HPPs cannot be considered financially attractive investment opportunities. In fact, if climate change impacts are considered in scenario (ii), the project IRR of the HPPs gets close to zero. The financial viability of the HPPs hence gets endangered. One needs to recall that both HPPs are analyzed together as one project finance model in this part of the SAVi assessment. The CBA and LCOE results presented in Section 4 were also calculated individually for each HPP. These results emphasized that a significantly higher fraction of dredging cost would occur for HPP Kalivaç, as it is the first of the two HPPs in the Vjosa River course. One can hence expect that the individual project IRR for HPP Kalivaç will be negative once the costs of dredging are considered, rendering the project not financially viable.

The HPPs are even less attractive from a societal point of view, as highlighted by performance results of scenario (iv) and (v). Explanations apply as in Section 5.2.

Table 12. Project IRR and project NPV for both HPPs, comparing results without BAU and with CC impacts

	Project NPV HPPs (both)		Project IRR HPPs (both)	
Scenario	**BAU**	**CC impacts**	**BAU**	**CC impacts**
(i) Baseline: Conventional results	(79.85)	(85.80)	9.32%	8.47%
(ii) Baseline + cost of dredging	(181.62)	(187.36)	3.15%	0.43%
(iii) Baseline + technology-specific externalities	(79.04)	(84.94)	9.36%	8.53%
(iv) Baseline + location-specific externalities	(262.16)	(280.45)	**negative**	**negative**
(v) Baseline + all externalities	(261.20)	(279.44)	**negative**	**negative**

5.2.3. NPV and IRR Results Under Different Electricity Price Assumptions

The results in Section 5.2 underline that the HPPs Poçem and Kalivaç cannot be considered attractive investment opportunities because of the negative NPV results under all analyzed cost scenarios and project IRR results that lie below the 13.5% threshold. In this section, a new set of results will be presented that are calculated based on new electricity price assumptions—all other assumptions presented in Section 5.1 remain stable. More specifically, two minimum average electricity prices were calculated to achieve the following:

1. NPV equals zero for the HPPs in the baseline scenario (i). This can be attained by an electricity price of EUR 78.47 per MWh. This is the lowest price that would make the NPV of the HPPs in baseline scenario (i) zero.
2. NPV equals zero for the HPPs in the cost scenario (ii). This can be attained by an electricity price of EUR 108.39 per MWh. If at least that price is paid for electricity generated by the HPPs, it will be an attractive investment opportunity even if the cost of dredging has to be borne by the project.

The SAVi financial models calculated how the three assets perform if the new electricity prices were to be received for electricity generated by each respective asset. Table 13 presents the project NPV results under varying electricity price assumptions, and Table 14 presents the corresponding project IRR results.

The electricity price of EUR 78.47 per MWh naturally means that the HPPs achieve an NPV of zero in the baseline scenario (i) and a corresponding project IRR of 13.5%. It is worthwhile highlighting that this project IRR is equal to the assumed WACC, which is used for discounting purposes and calculating the cost of financing (see Table 9). The solar PV system performs strongly under these new electricity price conditions and achieves positive project NPV results as well as project IRR results around 18%. This new electricity price would still not be sufficient for the onshore wind farm to generate a positive NPV, the project IRR is slightly better at around 9.5% compared to around 5% with an electricity price of EUR 55 per MWh.

The three assets perform significantly better if an electricity price of EUR 108.39 per MWh is assumed. As described above, this price was calculated to demonstrate what the minimum electricity price has to be for achieving a project NPV of zero under the condition that the HPPs have to cover the cost of dredging. Therefore, Table 13 indicates that the HPPs achieve this project NPV in scenario (ii). All assets yield positive project NPV results in scenarios (i) to (iii), even the onshore wind farm. The higher electricity price, however, would still not be sufficient to compensate for the negative externalities caused by the HPPs, as evidenced by the negative project NPV results in scenario (iv) and scenario (v).

Table 13. Reverse engineering—comparing the effects of different electricity price assumptions on the project NPV of the three assets under different cost scenarios

	Project NPV if electricity price EUR 55/MWh			Project NPV if electricity price EUR 78.47/MWh			Project NPV if electricity price 108.39 EUR/MWh		
Scenario	**HPPs (both)**	**Solar PV**	**On-shore wind**	**HPPs (both)**	**Solar PV**	**On-shore wind**	**HPPs (both)**	**Solar PV**	**On-shore wind**
(i) Baseline: Conventional results	(79.85)	(16.30)	(156.34)	0.00	60.25	(81.75)	101.77	157.81	15.80
(ii) Baseline + cost of dredging	(181.62)	n/a	n/a	(101.77)	n/a	n/a	0.00	n/a	n/a
(iii) Baseline + technology-specific externalities	(79.04)	(12.88)	(154.18)	0.81	63.67	(79.64)	102.58	161.23	17.92
(iv) Baseline + location-specific externalities	(262.16)	n/a	n/a	(173.48)	n/a	n/a	(71.72)	n/a	n/a
(v) Baseline + all externalities	(261.20)	(12.88)	(154.18)	(172.67)	63.67	(79.64)	(70.90)	161.23	17.92

The project IRRs of all assets appear convincing for scenarios (i) to (iii) in Table 14 given an electricity price of EUR 108.39 per MWh is paid. Each asset achieves an attractive risk–return profile. The project IRR of the HPPs even turns positive in scenarios (iv) and (v) if an electricity price of EUR 78.47 per MWh or EUR 108.39 per MWh is paid, achieving a project IRR of approximately 3.7% and approximately 9.8% respectively. The HPPs hence appear more favourable in this situation from a societal point of view, although it is important to recognize that negative externalities for affected stakeholders remain high, and the threshold project IRR of 13.5% is still not realized as a result. It is also significant that scenarios (iv) and (v) do not include the additional cost of dredging and the project IRR results of scenarios (iv) and (v) hence do not reflect this additional burden.

Finally, the results presented in Table 13 and Table 14 for the HPPs do not take into account the adverse impacts of climate change. The corresponding results under the two new electricity price assumptions are listed in Table C4 and Table C5 in Appendix C.

Table 14. Reverse engineering—comparing the effects of different electricity price assumptions on the project IRR of the three assets under different cost scenarios

	Project IRR if electricity price 55 EUR/MWh			Project IRR if electricity price 78.47 EUR/MWh			Project IRR if electricity price 108.39 EUR/MWh		
Scenario	**HPPs (both)**	**Solar PV**	**On-shore wind**	**HPPs (both)**	**Solar PV**	**On-shore wind**	**HPPs (both)**	**Solar PV**	**On-shore wind**
(i) Baseline: Conventional results	9.32%	12.23%	5.17%	13.50%	17.89%	9.49%	18.53%	24.37%	14.23%
(ii) Baseline + cost of dredging	3.15%	n/a	n/a	8.10%	n/a	n/a	13.50%	n/a	n/a
(iii) Baseline + technology-specific externalities	9.36%	12.50%	5.30%	13.54%	18.13%	9.60%	18.56%	24.59%	14.32%
(iv) Baseline + location-specific externalities	**negative**	n/a	n/a	3.71%	n/a	n/a	9.75%	n/a	n/a
(v) Baseline + all externalities	**negative**	12.50%	5.30%	3.77%	18.13%	9.60%	9.79%	24.59%	14.32%

5.3. Conclusion of the Financial Analysis

This financial analysis reveals that none of the three energy-generating assets achieve positive NPV results and therefore cannot be considered financially attractive investment opportunities under the condition that an electricity price of only EUR 55 per MWh will be paid. On the other hand, the project IRR results are positive for all three assets under this electricity price assumption, pointing to the fact that the projects are financially viable. They, however, do not achieve a convincing risk–return profile because the IRR results remain below the 13.5% threshold.

For the HPPs, the project IRR becomes negative, and the project NPVs demonstrate discouraging results once the monetary values of location-specific externalities are internalized into the financial model of the asset. This poor performance highlights the fact that the HPPs cannot be considered worthwhile investments from a societal point of view. If the impacts of climate change are considered on top, as presented in Section 5.3, the project NPV and the project IRR results are even getting worse under all cost scenarios analyzed. The financial performance of the HPPs will be adversely affected by climate change.

Finally, the financial analysis shows that an electricity price of at least EUR 78.47 per MWh must be earned by the HPPs to achieve an NPV of zero—this price, however, would still not cover sufficiently the cost of dredging that is expected to arise for the HPPs over their lifetimes. If this cost is meant to be covered sufficiently by revenues to achieve an NPV of zero, the electricity price would need to rise to EUR 108.39 per MWh. In all electricity price events, it can be concluded that the solar PV system performs significantly better than the HPPs—this is particularly true if the electricity price rises to EUR 78.47 per MWh or more. The solar PV system becomes the most viable and attractive investment opportunity, from both an investor's and society's point of view. This is not true for the HPPs. Neither does the onshore wind farm appear to be an attractive investment opportunity from a private investor's point of view—unless high electricity prices are realistic market conditions. Still, the onshore wind farm performs better than the HPPs throughout all analyzed electricity price events if the HPP assets need to bear the cost of dredging.

6.0 Hydropower Impacts on Biodiversity and Ecosystem Services along the Vjosa River

The construction and operation of HPP Kalivaç and HPP Poçem are expected to have cumulatively significant and long-lasting adverse impacts on biodiversity as well as the quality and quantity of ecosystem services downstream of the constructed dam sites and even more immediately on the surface areas that will be flooded for establishing large reservoirs for both HPPs. This section provides a brief qualitative description of expected impacts, presents reasons why these impacts could not be valued (and hence not integrated into this assessment), and finally points to some studies that demonstrate how a valuation of ecosystem services loss and destruction of biodiversity could be delivered.

6.1. Biodiversity Threats: Loss of Habitats and Species Diversity

The Vjosa catchment is characterized by undisturbed river dynamics and distinct river-floodplain ecosystems. Many of Vjosa's typical riverine habitats are listed in Annex 1 of the European Union Habitats Directive, approximately 177 species of the examined flora and fauna are cited by the Bern Convention (EcoAlbania, Euronatur & RiverWatch, 2018), more than 15 habitats are recognized as priority habitat types (Natura, 2000), and seven habitat priority types are of high floristic value (European Nature Information System) (Shumka et al., 2018). These facts highlight the excellent conservation status of the river catchment and confirm that the conservation of an undisturbed Vjosa River is of broad European significance (Schiemer et al., 2018). The primary field research and studies conducted by Schiemer et al. (2018) provide evidence of the geomorphological dynamics, habitat types and relationships, population dynamics and density as well as diversity of species. Initial findings of this and other studies indicate the occurrence of many fish species that are highly dependent on the range of connected river habitats (Shumka et al., 2018), more than 90 taxa of aquatic invertebrates, and almost 400 taxa of terrestrial species (including the European otter). While many of these are endemic to the Balkans, some species have been discovered for the first time, and a range of the invertebrates belong to the most endangered aquatic species on a European scale (Schiemer et al., 2018).

However, the planned HPPs Kalivaç and Poçem in the central part of the Vjosa River threaten this unique feature of the river. The above-cited habitat and species diversity is expected to significantly decline, and many species are anticipated to disappear as a result of landscapes flooded to establish the HPP reservoirs and construct massive dams for the HPPs that will cause riverbed incision and alter the river geomorphic and fluvial dynamics, water levels, sediment transport, and overall ecological conditions for habitat succession (Schiemer et al., 2018; Shumka et al., 2018). Such biodiversity threats are also recognized in the EIA conducted for HPP Kalivaç (Abkons, 2019a). For example, the alteration of river dynamics due to reservoirs and construction of dams—as well as the fact that large hydropower dams are insuperable barriers—will disrupt the habits of migratory fish species such as the critically endangered European eel (Anguilla Anguilla) and will destroy fish spawning and rearing habitats. The European eel is just one species whose decline over the last decades is highly associated with the growing number of hydropower dams in Europe (Shumka et al., 2018).

Another ecological threat associated with HPPs Kalivaç and Poçem is related to the fact that both are constructed as storage plants with dams and large reservoirs to be able to produce baseload and peak load electricity. At the same time, the Vjosa River is known to transport large volumes of sediment that will accumulate in the reservoirs, necessitating a sediment-management strategy by plant operators to maintain the reservoirs and HPP at the best operating capacity. Costly sediment dredging has been discussed as one option in Sections 3 and 4. Another option to maintain the operating capacity and remove sediments from reservoirs to allow for less disrupted river ecosystems downstream is reservoir flushing by opening the bottom gates of dams. However, there severe ecological consequences for aquatic life caused by such reservoir flushing, including direct fish killings and destruction of spawning areas (Hauer et al., 2019).

6.2. Degradation of Ecosystem Services

Deterioration of Drinking and Irrigation Water Supply

In terms of adverse impacts on ecosystem services directly relevant for local communities, drinking water supply will deteriorate in quality and quantity because of negative groundwater impacts when establishing the HPP reservoirs and operating both plants over time. The decrease in drinking water supply has negative socioeconomic consequences for villages in proximity to the HPPs (such as Kordhaj village) as well as for the town of Fieri (Miho et al., 2018). Likewise, studies (as well as the EIAs conducted for HPP Kalivaç and HPP Poçem) note that water supply for irrigation purposes may decline in quantity and quality because of shifting downstream water levels and deteriorating surface water quality (Abkons, 2019b; GR Albania, 2015). This might have adverse impacts on local agriculture production (aside from the foregone agriculture production because of inundated surface area as assessed in this study). On the other hand, there are indications that water stored in the HPP reservoirs might be used directly for irrigation purposes downstream of the reservoirs. This might be sufficient to compensate for the declining availability and quality of surface water downstream.

Despite pointing to the adverse impacts on water supply, the existing studies do not estimate in quantitative terms how much drinking water supply and irrigation water supply will decrease over time.

Flood Protection Loss

It is anticipated that compared to the status quo of an intact Vjosa River, the construction of HPPs Kalivaç and Poçem will cause a downstream loss of retention zones and wetlands that will increase the probability of catastrophic floods (Miho et al., 2018).

Loss of Recreational Value and Tourism Potential

The disrupted sediment transport when setting up dams for hydropower generation will cause coastal erosion at the coastline of the Adriatic Sea that currently benefits from sediment transport maintained by an intact Vjosa River. In particular, coastal dunes in both parts of the Vjosa delta as well as the adjacent Narta lagoon will be adversely affected by disrupted sediment transport (Miho et al., 2018). The coastal erosion and associated degradation and potential disappearance of wetlands, dunes, beaches, and lagoon landscapes, such as the Vjosa-Narta Protected Landscape which is recognized as the second most important site for birds in Albania, will not only lower the intrinsic value people associate with these natural sights but will also have hampering effects for recreational opportunities and the service-providing tourism sector (Hauer, et al., 2019). However, quantitative data is lacking concerning the extent and speed of coastal erosion, and too little is known about today's recreational value that Albanian and international tourists derive from the affected coastal region.

6.3. Valuation of Biodiversity Loss and Ecosystem Services Degradation

The explanations and studies cited above illustrate that severe consequences for biodiversity and the continuous provision of ecosystem services are to be expected if construction and operation of HPP Kalivaç and HPP Poçem move ahead. To arrive at a monetary valuation of such impacts and thus integrate these factors into a CBA, LCOE, or financial performance assessment requires different steps of collecting quantitative data, processing these data, and monetizing forecasted impacts. Quantitative data concerning the status quo of biodiversity and ecosystem services at the sites of the HPPs as well as downstream need to be collected as further described by Schiemer et al. (2018). After this, sophisticated economic methodologies for monetizing present biodiversity and ecosystem services need to be applied. Ultimately, the collection of quantitative evidence for anticipated or forecasted impacts of HPPs on biodiversity and ecosystem services must take place, drawn from either historic time series data of comparable sites or from prognostic models customized for the HPPs Kalivaç and Poçem to forecast future impacts.

None of these elements are sufficiently available for the Vjosa River and the planned HPPs. The studies cited above provide some data on the status quo of the river ecosystem and existing species. However, data collection conducted for these studies relied on limited time periods, and no quantitative estimates are provided regarding the extent to which populations of species decline or which ecosystem services decline when, to what degree, and in which area of the river course: such quantitative estimations are unfortunately also not available in the EIAs conducted for both HPPs. Without the availability of such data and a lack of short-, medium-, and long-term estimations of biophysical impacts, it is impossible to apply monetization methods.

Nevertheless, it is certainly possible to conduct the above-listed steps for the Vjosa River to arrive at a valuation of the current biodiversity and ecosystem services status as well as to estimate the adverse impacts of the HPPs on biodiversity and ecosystem services in monetary terms. A range of studies have been conducted for the valuation of biodiversity and ecosystem services in specific locations—a few that appear relevant for the context of HPP development along the Vjosa River are mentioned below to illustrate how a valuation could be approached.

Biodiversity Loss

The adverse impacts of HPP Poçem and HPP Kalivaç on local biodiversity in areas of the reservoir and further downstream, including disruptive impacts on flora, fauna and habitats, are expected as described in Section 6.1 and as evidenced by many studies conducted for HPPs in other regions. Aside from the described need to first survey the status quo of local biodiversity and forecast the biophysical dimensions of HPPs' adverse impacts, the monetary valuation of biodiversity is challenging because market prices or easily quantifiable opportunity costs are usually absent. Because biodiversity can be considered a non-market good characterized by the absence of an "objective" valuation, it is inevitable that valuation methods involve surveying people who associate a value with the biodiversity components under consideration or can state according preferences. Viable methods that can be applied to value the adverse biodiversity impacts of hydropower are stated preference techniques, such as choice experiments (Han et al., 2008; Botelho et al., 2015) and contingent valuations (Aravena et al., 2012). The studies also serve as examples of how a valuation of adverse biodiversity impacts could be approached in the Vjosa River context. Each valuation method has advantages and disadvantages in terms of valuation adequacy as well as the expertise and time resources required for appropriate application. Nevertheless, it is preferable to conduct local primary research because valuation results for biodiversity based on stated preference techniques have limited transferability to other contexts.

Deterioration of Drinking and Irrigation Water Supply

The deterioration of drinking water and irrigation water quality and quantity could be valued in various ways, for example, by estimating the level of water quality and quantity loss, the number of people and farms affected, current water consumption levels that would need to be replaced, and the costs of alternative freshwater supply (cost of bottled water, the cost for new municipal water supply infrastructure, the cost for sewage treatment plants to replace water self-purification function of the Vjosa River). Wang et al. (2010) present such a valuation methodology, among others, for additional and foregone water supply services caused by HPPs and illustrates this methodology by valuing the positive and negative ecosystem services impacts of three HPPs in China.

Flood Protection Loss Due to Degradation of Wetlands

Deterioration and disappearance of wetlands downstream of HPPs Kalivaç and Poçem are anticipated. Figure 1 indicates the locations of present wetlands. These are known to provide, among others, flood protection services (Miho et al., 2018). Peh et al. (2014) provide an example of how ecosystem services provided by restored wetlands of the Wicken Fen National Nature Reserve in the United Kingdom were valued, among others, based on their flood storage capacity and corresponding services for avoided damages to crops and properties. This value of this ecosystem service was estimated at USD 48 per hectare per year. Other valued ecosystem services provided by these wetlands are recreation, grazing sites for animals of commercial farmers, and carbon sequestration.

However, the value estimates of these ecosystem services provided by wetlands are location-specific, as they depend on the quantification and monetization of various conditional ecological as well as economic factors. A summarizing report by Schuyt & Brander (2004) tries to resolve the need to collect local data by providing average economic values per wetland type and region. Values presented in that report could be a starting point for valuing lost ecosystem services along the Vjosa River once the size of wetland loss due to HPP construction and operation is estimated.

Loss of Recreational Value and Tourism Potential

This SAVi assessment provided one approach to valuing the foregone tourism potential by assuming that a Wild River National Park could not be established if the HPPs are constructed, leading to an assumed level of foregone tourism visits and spending (described in more detail in Section 3 and corresponding monetary results are presented in Section 4).

The valuation of lost recreational value and tourism potential could be extended to assessing the value that local people associate with visiting the undisturbed Vjosa River and by estimating the decline in tourism numbers over time if coastal erosion and disappearance of dunes, beaches, and lagoons occur due to disrupted sediment transport in the Vjosa River (as described above). Various methods exist to quantify the recreational value of nature, including revealed preferences approaches such as the travel cost method and hedonic pricing. In addition, stated preference approaches exist that apply contingent valuation methods. All methods imply the need to conduct primary data collection for the specific location. While transferability of valuations conducted for other locations is very limited, Sousa et al. (2019) describe in more detail, among other things, the above-listed valuation approaches, referring to several studies that have been conducted to value the impacts of HPPs on recreational activities and tourism. The cited studies helpfully illustrate how an appropriate valuation could be conducted for the Vjosa catchment and coastal areas.

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Appendix A. Data Sources and Assumptions

Table A1. Technical data for HPP Poçem and HPP Kalivaç

Parameter	Unit	HPP Poçem	HPP Kalivaç	Data Source/Comment
Installed capacity	MW	99.6	111.0	Concession Agreement Kalivaç (Notary Chamber Tirana, 2019); Concession Agreement Poçem (Ministria E Energjise Dhe Industrise, 2016). Estimates based on annual generation and load factor.
Construction time	Years	2	2	Assumption
Operation time	Years	60	60	Assumption
Concession	Years	35	35	Concession Agreement Kalivaç (Notary Chamber Tirana, 2019); Concession Agreement Poçem (Ministria E Energjise Dhe Industrise, 2016).
Electricity generation (annual)	MWh/ Year	305,400	366,600	Concession Agreement Kalivaç (Notary Chamber Tirana, 2019); Concession Agreement Poçem (Ministria E Energjise Dhe Industrise, 2016). EIA Kalivaç (Abkons, 2019b)
Assumed load factor	%	35.0%	37.7%	The load factors for the HPPs are calculated based on projected production and indicated installed capacity.
Employment from construction	FTE/MW	10.8	10.8	(Rutovitz & Atherton, 2009) & (Wei et al., 2010)
Employment from O&M	FTE/MW/ Year	0.2036	0.2036	(Rutovitz & Atherton, 2009) & (Wei et al., 2010)
Employment from road construction	FTE/km	7.78	7.78	(Construction Industry Development Board [CIDB], 2005)
Employment from road maintenance	FTE/km/ Year	6	6	(CIDB, 2005)
Average salary in Albania	ALL/ Person/ Year	540,000	540,000	According to the Municipality of Tirana, the average monthly salary in Albania was ALL 45,000 (Bashkia Tirane, 2019). Assuming 12 salaries per year, this amounts to ALL 540,000 per person per year.

Parameter	Unit	HPP Poçem	HPP Kalivaç	Data Source/Comment
Share of income discretionary	% of salary	24.6%	24.6%	Based on NUMBEO (2019) and the disaggregation of costs, the non-discretionary items are rent (17.2%), markets (32.6%), transportation (16.2%) and utilities (9.4%). Discretionary spending assumes restaurants (12.5%), sports and leisure (7.4%), and clothing and shoes (4.7%). The total share of assumed discretionary spending is hence 24.6%.

Table A2. **Technical data for solar PV and onshore wind**

Parameter	Unit	Solar PV	Onshore Wind	Data Source/Comment
Installed capacity	MW	435.9	264.5	The installed capacity of solar and wind is estimated to match the aggregated electricity production of the two HPPs Poçem and Kalivaç.
Construction time	Years	2	2	Assumption
Operation time	Years	25	25	Assumption
Electricity generation (annual)	MWh/ Year	672,000	672,000	Electricity generation for wind and solar is assumed to be the sum of annual electricity generated by the two hydropower assets.
Assumed load factor	%	17.6%	29.0%	(IRENA, 2018)
Employment from construction	FTE/MW	12.7	7.5	(Rutovitz & Atherton, 2009) & (Wei et al., 2010)
Employment from O&M	FTE/MW/ Year	0.3081	0.7398	(Rutovitz & Atherton, 2009) & (Wei et al., 2010)
Employment from road construction	FTE/km	7.78	7.78	(CIDB, 2005)
Employment from road maintenance	FTE/km/ Year	6	6	(CIDB, 2005)
Average salary in Albania	ALL/ Person/ Year	540,000	540,000	According to the Municipality of Tirana, the average monthly salary in Albania was ALL 45,000 (EUR 360). Assuming 12 salaries per year, this amounts to ALL 540,000 per person per year.

Parameter	Unit	Solar PV	Onshore Wind	Data Source/Comment
Share of income discretionary	% of salary	24.6%	24.6%	Based on NUMBEO (2019) and the disaggregation of costs, the non-discretionary items are rent (17.2%), markets (32.6%), transportation (16.2%) and utilities (9.4%). Discretionary spending assumes restaurants (12.5%), sports and leisure (7.4%), and clothing and shoes (4.7%). The total share of assumed discretionary spending is hence 24.6%.

Table A3. Financial data for HPP Poçem and HPP Kalivaç

Parameter	Unit	HPP Poçem	HPP Kalivaç	Data Source/Comment
Capital cost	EUR/MW	1,375,353	1,253,153	Concession Agreement Kalivaç (Notary Chamber Tirana, 2019); Concession Agreement Poçem (Ministria E Energjise Dhe Industrise, 2016)
O&M cost	EUR/MW/Year	30,258	27,569	Assumption that the annual O&M cost are a 2.2% share of capital cost for large HPPs (IEA & OECD, 2010)
Concession payments	% of annual revenue	2.2%	2.1%	Concession payments are calculated as fees that apply to total revenues generated, regardless of profitability. Percentages based on Concession Agreement Kalivaç (Notary Chamber Tirana, 2019); Concession Agreement Poçem (Ministria E Energjise Dhe Industrise, 2016).
Corporate tax rate	% of net profit	15.0%	15.0%	The 15% corporate tax rate in Albania applies to net profits (PwC, 2020)

Table A4. Financial data for solar PV and onshore wind

Parameter	Unit	Solar PV	Onshore Wind	Data Source/Comment
Capital cost	EUR/MW	500,000	1,360,000	(Kost et al., 2018), (IRENA, 2019)
O&M cost	EUR/MW/Year	14,100	38,300	(IRENA, Joanneum Research, & University of Ljubljana, 2017)
Corporate tax rate	% of net profit	15.0%	15.0%	The 15% corporate tax rate in Albania applies to net profits (PwC, 2020)

Table A5. Employment- and income-related data for all technologies

Purpose of collected data and assumptions: The figures below serve to calculate and value the following parameters of this SAVi assessment, which are explained in more detail in Section 3:

(8) Discretionary spending from employment for energy capacity,

(9) Discretionary spending from employment for road construction,

(13.3) Foregone discretionary spending from lost agriculture employment.

Parameter	Unit	HPP Poçem	HPP Kalivaç	Solar PV	Onshore Wind	Data Source/Comment
Employment from construction of energy capacity	FTE/MW	10.8	10.8	12.7	7.5	(Wei et al., 2010)
Employment from O&M for energy capacity	FTE/MW/year	0.2036	0.2036	0.3081	0.7398	(Wei et al., 2010)
Average salary	EUR/person/year	4,320				According to the Municipality of Tirana.
Employment from road construction	FTE/km	7.78				Figures for labour-based methods and technologies for employment-intensive construction works (CIDB, 2005)
Employment from road maintenance	FTE/km/year	6				
Employment per hectare (ha) of agriculture land	Person/ha	0.15796				Estimated based on World Bank data (2019b) on total agriculture land, labour force, employment rate, and share employed by sector in Albania.
Share of income discretionary	% of salary	24.6				Calculations for the share of discretionary spending based on NUMBEO data (2019) for Albania. The calculated percentage serve to estimate the discretionary spending resulting from employment for energy capacity, road construction and maintenance, see positions (8) and (9) Section 3. Likewise, it serves to estimate the foregone discretionary spending associated with impeded agriculture production, see position (13.3) in Section 3.

Table A6. Input data for the estimation of compensations to be paid to parties affected by inundation for the hydro reservoirs

Purpose of collected data and assumptions: Below figures serve to calculate and value the compensations to be paid to parties affected by inundation for the hydro reservoirs. This is explained further under position (6) in Section 3.

Parameter	Unit	HPP Poçem	HPP Kalivaç	Data Source/Comment
Affected agriculture land	ha	380	380	Data for the area affected by the HPPs obtained from the concession agreement for HPP Poçem (Ministria E Energjise Dhe Industrise, 2016). The same data are assumed to apply for HPP Kalivaç as well due to the absence of specific information for HPP Kalivaç.
Affected residential land	ha	5	5	
Affected number of structures	Houses	17	17	
Compensation cost per hectare of agriculture	ALL/ha	1,200,000		Data obtained from the concession agreement for HPP Poçem (Ministria E Energjise Dhe Industrise, 2016).
Compensation cost per hectare of residential land	ALL/ha	4,500,000		
Compensation cost per affected structure	ALL/ House	380,000		

Table A7. Input data to estimate GHG emissions from both hydro reservoirs

Purpose of collected data and assumptions: The figures below serve to calculate and value the reservoir-related net greenhouse gas (GHG) emissions from Poçem and Kalivaç reservoirs, explained further under position (12) in Section 3.

Parameter	Unit	HPP Poçem	HPP Kalivaç	Data Source/Comment
Direct land use	ha/MW	23.592	14.414	The direct land use of the HPPs comprises the area used for the technical facilities as well as the area inundated for setting up the reservoirs. Estimations are based on the area covered by HPP Kalivaç which amounts to approximately 1,600 ha (Abkons, 2019b) and HPP Poçem which amounts to approximately 2,350 ha (EcoAlbania, Euronatur & RiverWatch, 2016). The parameter in this table is indicated per MW.
GHG emissions caused by hydropower reservoirs	ton/ha/Year	5.3246	5.3246	The GHG emission data are based on Samiotis et al. (2018), using the average net GHG emission values caused by the Ilarion dam and reservoir project in Western Macedonia, Greece. The study is considered a reasonable approximation of net GHG per ha of reservoirs area for HPPs Poçem and Kalivaç as they are located in the same climatic zone and similar geographic conditions as the Ilarion project. To remain consistent with conditions found for the Ilarion project, it is assumed that existing vegetation on the surface areas to be covered by Poçem and Kalivaç reservoirs will be cleared prior to inundation. This appears a reasonable assumption as vegetation clearance is also recommended by the ESIA Scoping study conducted for HPP Kalivaç as a strategy to reduce GHG emissions from the Kalivaç reservoir (Abkons, 2019a).
Social cost of carbon	USD/MWh	31		The social costs of carbon (SCCs) are the economic cost caused by an additional ton of carbon dioxide emission or its equivalent through the carbon cycle. This is a top-down assessment of the cost of carbon. The BAU valuation for the SCC is USD 31 (constant) as indicated in Nordhaus (2017). This cost is used to value the carbon dioxide equivalent emissions caused by the two reservoirs and hence serve to calculate position (12) explained in Section 3.

Table A8. **Tourism-related data to estimate negative externalities on tourism potential caused by HPPs Poçem and Kalivaç**

Purpose of collected data and assumptions: All figures below serve to calculate the foregone tourism potential if HPPs Poçem and Kalivaç are built. See details under position (14) in Section 3.

Parameter	Unit	HPPs Poçem & Kalivaç	Data source/comment
Number of tourists visiting a Vjosa Wild River National Park	Person/ Year	5,000	Conservative assumption
Growth rate tourism	%/Year	1.50%	Conservative assumption
Value added per tourist	ALL/ Tourist/ Year	24,217.13	Value added per tourist
Average length of stay	Days/ Person	4.3	Average length of stays in Albania for 2014–2017 period (INSTAT, 2019).
Average spending per tourist day	EUR/ Person/ Day	52	Figures based on Albania´s National Strategy for Sustainable Tourism Development 2019–2023 (Ministry of Tourism and Environment, 2019) and collected tourism data for Albania (INSTAT, 2019).
Share of spending for accommodation	%	20%	
Share of spending for Food	%	68%	
Share of spending for transport and other services	%	13%	
Sales tax rate	%	20%	
Profit tax rate accommodation	%	6%	
Profit tax rate food and other services	%	20%	
Employment per tourist	Person/ tourist	0.01827	Figures calculated based on 2017 tourist numbers for Albania amounting to 5.12 million (INSTAT, 2019) and the number of people directly employed in Albania´s tourism sector (Ministry of Tourism and Environment, 2019).
Share of income discretionary	% of salary	24.6	Calculations for the share of discretionary spending in Albania based on NUMBEO data (2019). The calculated percentage serve to estimate the foregone discretionary spending associated with impeded tourism activity, see position (14.3) in Section 3.

Table A9. **Input data for calculating cost of sediment dredging for HPPs Poçem and Kalivaç**

Purpose of collected data and assumptions: The figures below serve to calculate and value the cost of dredging during and after the concession period of both HPPs, explained further under position (7) and position (11) in Section 3.

Parameter	Unit	HPPs Poçem & Kalivaç		Data source/comment
Sediments carried by river	ton/ Year	2.7 million		Sedimentation is calibrated based on the sedimentation study published by Hauer et al. (2019). According to estimates provided in the study, the Vjosa River carries at least 3 million tons of sediment per year to the coast. A slightly lower estimate was used in this assessment to approximate the amount of sediment that will arrive in the HPP reservoirs given that the reservoirs are not located at the end of the river course. It serves to estimate the cost of dredging during and after the concession agreement. It needs to be noted that no data was available on future expected erosion. It could be the case that erosion and hence sediment transport amounts increase, depending on climate change impacts (for example, more erratic rainfall) and land use changes. Due to no available data, the SAVi model built for this assessment assumes that erosion and sediment transport depends on water flow and the amount of water that reaches the reservoirs. See positions (7) and (11) in Section 3 for more details on how sediment transport affects the HPPs.
Cost per ton of sediments removed	EUR/m³	7.5	7.5	According to Hauer et al. (2019), the cost of dredging typically ranges between EUR 5 to EUR 10 per ton extracted, depending on approach used and logistics required. The average cost of EUR 7.5 per ton was assumed for this assessment to estimate the cost of dredging during and after the concession agreement, see positions (7) and (11) in Section 3 for more details.
Removal of sediment from reservoirs	% of sediment removal/ year	25	25	This is an assumption which suggests that every year 25% of the sediment that accumulates in each of the two HPP reservoirs will be removed through dredging in order to maintain the operational capacity of each HPP for electricity generation. Based on the above information about the amount of sediment carried by the Vjosa River, this implies that over the first 10 years of the SAVi simulation additional amounts of sediment will keep accumulating in the reservoirs. By the end of year 10 of operation, approximately 12.07 million tons and 1.59 million tons of sediments will have accumulated in Kalivaç and Poçem, respectively. Afterwards, the total amount of sediments in the two reservoirs remains relatively constant at 10.53 million tons (Kalivaç) and 1.39 million tons (Poçem) as the amount dredged is equal to the amount of sediment newly entering the reservoirs. If climate change projections on precipitation are considered (see Section 4.1.3), the amount accumulated in the Kalivaç and Poçem reservoirs totals 11.52 million tons and 1.52 million tons by the end of year 10 of operation respectively. This is due to the reduced average precipitation resulting in less water volume and less sediment transport in the Vjosa River. After year 10, the average amount of sediment in the reservoirs remains relatively constant at approximately 9.9 million tons and 1.3 million tons, respectively. See positions (7) and (11) in Section 3 for additional information.

Table A10. Revenue data for all energy-generation technologies

Purpose of collected data and assumptions: Below figures serve to calculate the revenue streams of all assessed energy generation technologies, explained further under position (15) and position (16) in Section 3.

Parameter	Unit	All technologies	Data source/comment
Offtake electricity price	EUR/ MWh	55	As per the Albanian regulatory framework, HPPs larger than 15 MW do not qualify for the feed-in tariff set by the Albanian Energy Regulatory Office (ERE). The offtake price for large concession based HPPs is typically a bilateral agreement between the producer and the offtaker, which is confidential and not public information. Note that the final power offtake price would be influenced by whether the power is exported to other markets where prices are higher as compared to Albania. However, for the purpose of this study, it is assumed that the HPPs will serve the domestic market, and therefore a regional average offtake electricity price is taken as a base. Given that Albania does not have a power exchange, the Hungarian Power Exchange (HUPX) is often taken as a reference (Hungarian Power Exchange, 2020). Offtake prices for renewable alternatives are guided by the recent developments in Albania whereby the government seeks to develop large-scale solar PV projects through competitive tendering processes (Bellini, 2020). Accordingly, the price of EUR 55 per MWh was set while assuming that this price will stay constant over the lifetime of each respective asset.
Carbon credits from avoided grid emissions	EUR/ ton CO_2eq. avoided	5	This price figure is a conservative assumption based on recent development in the carbon offset market (World Bank, 2019a). It serves to calculate the revenues due to generated carbon credits from avoided grid emissions, see position (16) in Section 3 for details.

Appendix B. SAVi Customization for Hydropower

Systems Thinking and System Dynamics

The SAVi model is developed using the system dynamics methodology. 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, customized with local stakeholder input and parametrized with local, accessible data. The model simulates the period 2000 to 2082. There are two main reasons for using this specific timeframe: (i) being causal-descriptive, SAVi needs to be validated against historical data (hence the simulation of the model from 2000 onwards), (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. The HPPs assessed in this SAVi assessment have a lifetime of 60 years and are assumed to start operating in year 2023—this is why the model simulates until the end of 2082.

IISD used and customized the SAVi energy model for the analysis of the HPPs Kalivaç and Poçem and the alternative energy generating assets, solar PV, and onshore wind. The assessment monetizes the impacts climate change has on the HPPs, as well as the environmental, social, and economic externalities caused by each of the assessed energy generating assets.

System Dynamics Model Overview

The CLD of the generic SAVi energy model is displayed in Figure 4. Note that elements that were customized in the SAVi energy model for this particular assessment and that are captured by the quantitative system dynamics model (such as concession payments and cost of dredging to be paid by HPPs or the range of technology- and location-specific externalities) are not displayed in this Figure 4. The customized CLD is displayed in Figure 2 in the main body of this report. Most dynamics of the generic CLD shown in the below figure are relevant for this study, aside from the macroeconomic drivers of change (e.g., population and GDP affecting electricity demand). There are four major feedback loops that drive the dynamics of the energy sector, loops (R1), (R2) and (B1), (B2). The character (R) represents a reinforcing loop and the character (B) represents a balancing loop; detailed definitions of these feedback loops and explanations how to design and read a CLD are described below Figure 3.

- Loops (R1) and (B1) represent the adjustment of power generation capacity. The current amount of capacity, renewable and non-renewable, is compared to the required amount of capacity to provide the desired electricity supply. The gap between current and desired capacity determines the required investments in the respective technology types.

- The desired capacity level depends on the average effectiveness, also called average load factor, of the current energy technology mix. If the load factor of newly added energy generation infrastructure is higher than the load factors of the current energy technology mix, it will increase the average load factor, which is captured by loop (R2). Renewable energy technologies are less efficient compared to thermal technologies due to their dependency on, for example, sunlight and wind speed, captured by loop (B2). Consequently, a transition toward more renewables likely requires the installation of higher capacity than an energy system primarily based on thermal technologies. For this specific SAVi application, the difference in load factor of the three considered renewable energy assets is taken into account, and the corresponding capacity is calculated.
- The price of electricity is the third major driver affecting the demand for power generation capacity (via demand for electricity). On the other hand, the impact of price on demand (and hence sales) is not considered when a single asset is analyzed. The underlying assumption is that all electricity generated is sold.

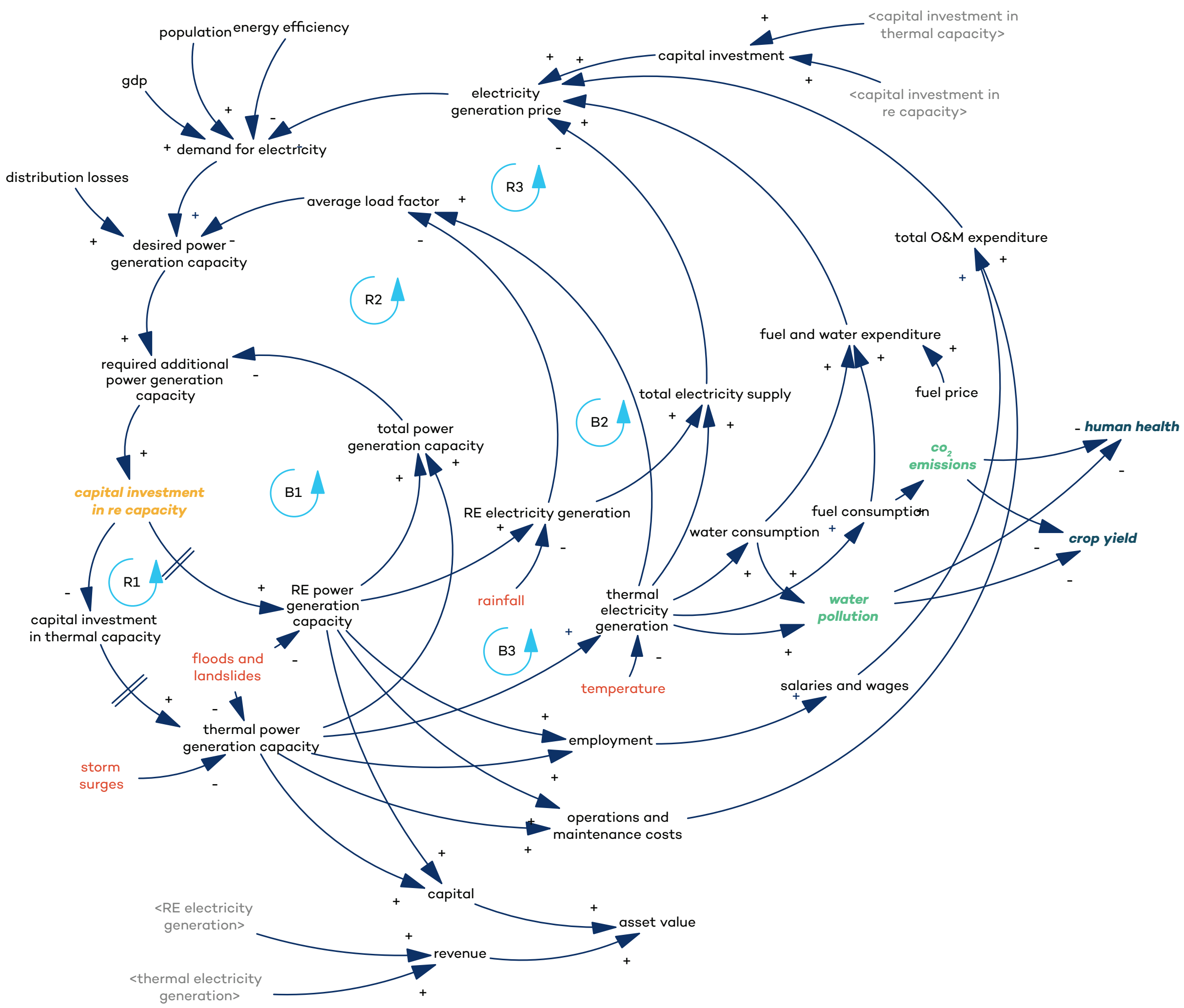

Figure B1. Causal Loop Diagram SAVi energy model

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 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 (TEEB, 2018; Pittock et al., 2016). 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 (UNECA, 2018).

To design solution-oriented and effective interventions, CLDs need to capture 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.:

- 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" (Bassi, 2009).

Table B1. 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 an 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 (TEEB, 2018). These mapped relationships may not necessarily indicate linear behaviour, and potential impacts may occur delayed, 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, and therefore where decision-makers will need to direct their efforts for finding a solution—along with being aware of how this solution will affect the rest of the system (WWF-Greater Mekong, 2014).

LCOE Calculation Method

The LCOE serves as the key indicator for each of the energy-generating technologies. It is a useful indicator for comparing the unit cost of different technologies over their lifetime (IEA & NEA, 2015). It is calculated by dividing the net present costs of generation over the lifetime of capacity by the net present generation. In other words, it is calculated by dividing cumulative discounted costs (i.e., USD) by cumulative discounted generation, typically indicated in MWh.

To fully account for the impact of power generation capacity, it is necessary to regard capacity as part of the system rather than in isolation. A system dynamics model assesses and monetizes asset-related externalities and risks, such as climate impacts on generation efficiency, transitional risks (e.g., carbon tax) and health impacts from particle and other emissions. This information is used to complement the traditional LCOE assessment and to determine the "real social, economic and environmental costs" of power-generation technologies. In addition to the conventional LCOE, including cost parameters such as capital investment, O&M, and fuel costs, an integrated LCOE is presented that considers the monetized externalities and risks related to each technology. This approach allows a full account of asset-related impacts and provides a holistic picture of capacity-related advantages and disadvantages.

The LCOE of power generation options depends on a variety of factors, such as upfront capital intensity, O&M costs, total generation, and the lifetime of the asset. The traditional LCOE is calculated using the following equation:

$$LCOE = \frac{\sum[(CAPEX_t + OPEX_t + Fuel_{t_t}) * (1 + r)^{-t})]}{\sum MWh * (1 + r)^{-t}}$$

where the different parameters indicate

LCOE = the levelized costs of generating one MWh of electricity over the lifetime of the asset

MWh = the amount of electricity generated by the asset in megawatt-hours

$(1+r)^{-t}$ = the discount factor for year t to discount capital and O&M costs and generation equally

r = the discount rate applied for the discounting of costs and generation

$CAPEX_t$ = the capital cost in year t

$OPEX_t$ = the operation and maintenance costs in year t

$Fuel_t$ = the fuel costs in year t

To convey a more holistic assessment, the SAVi assessment includes transitional risks (e.g., carbon tax), climate risks, and various externalities in the calculation in addition to the conventional assessment. The additional parameters considered in this analysis are presented in Section 3. These parameters have been identified in collaboration with local stakeholders and project owners, and belong to one of the three different categories: expenditure, avoided costs, and added benefits.

Financial Analysis: Project finance model overview

The main purposes of a project finance model are: (i) to identify the optimal capital structure, (ii) to assess the financial viability of the project, and (iii) to calculate the expected return on investment under different operational and risk scenarios.

i) Project sponsors use financial models to determine what the optimal debt-equity split used in the financing of the project should be. This largely depends on the project's revenue and cost profile: the timing and size of incoming cash flows during operations and the associated costs in each period. Most infrastructure projects follow a so-called "J-curve": having high upfront costs and relatively small but steady revenue streams. The "J" represents a certain number of years before the project breaks even and generates a return on investment.

ii) Project finance models can also calculate whether the cash flows generated by the project will be sufficient to service the debt and generate an attractive risk-adjusted return for both equity and debt investors. This assessment includes the calculation of key performance indicators such as the IRR and the NPV. The definition of these indicators can be found in the glossary.

iii) Project finance models are also well placed to stress test projects and assess how the expected return changes under certain operational and risk scenarios. This is calculated by a so-called "scenario table," which modifies key project assumptions and shows how key financial indicators react to these changes. Scenarios could be simple operational events, such as an increase in the price of feedstock, disruption in operation, or more complex climate events, such as heatwaves, sea-level rise, or carbon tax.

The project finance model used in SAVi is built in Microsoft Excel and follows Corality SMART best practices in order to improve the readability and auditability of the model by a third party. The outputs of the system dynamics model in SAVi are used as inputs in the project finance model and vice versa. The system dynamics model quantifies and monetizes the relevant environmental, social, and economic externalities associated with the project. It also helps identify the scenarios used in the scenario table. Depending on the purpose of the assessment and the target audience, some of the externalities are included as costs or benefits in the scenario table. Outputs of the system dynamics model can also change some of the key assumptions of the project finance model.

The main outputs of the project finance model are the financial indicators mentioned earlier. During the customization of the model, the list of indicators can be changed or extended as needed. Project-specific data, such as cost of financing, can also be extracted from the project finance model and fed back into the system dynamics model.

Appendix C. Complementary SAVi Results

Table C1. Itemized LCOE (EUR/MWh) of the two HPPs, comparing results of a 35-year period to results of a 60-year time period

LCOE Categories (EUR/MWh)	**HPPs (both), weighted average**		**HPP Poçem**		**HPP Kalivaç**	
	35 years	**60 years**	**35 years**	**60 years**	**35 years**	**60 years**
Conventional cost positions						
(1) Capital cost	60.05	59.31	65.56	64.76	55.45	54.78
(2) O&M cost	9.04	9.04	9.87	9.87	8.35	8.35
(3) Concession payments	1.74	1.71	1.91	1.89	1.59	1.57
(4) Corporate taxes	1.68	1.74	1.51	1.57	1.82	1.89
(5) Cost of financing	28.28	27.97	30.88	30.54	25.83	26.12
(6) Compensation payments	1.18	1.18	1.15	1.15	1.21	1.21
(7) Cost of dredging*	39.19	38.71	10.02	9.90	63.49	62.72
Subtotal (A): Conventional LCOE	**141.16**	**139.68**	**120.91**	**119.69**	**157.74**	**156.63**
Externalities						
Externalities (technology-specific)						
(8) Discretionary spending: employment energy capacity	(1.22)	(1.21)	(1.27)	(1.26)	(1.18)	(1.17)
(9) Discretionary spending: employment roads	(0.10)	(0.07)	(0.05)	(0.05)	(0.14)	(0.09)
Subtotal (B): Value of technology-specific externalities	**(1.32)**	**(1.28)**	**(1.32)**	**(1.31)**	**(1.33)**	**(1.26)**

LCOE Categories (EUR/MWh)	**HPPs (both), weighted average**		**HPP Poçem**		**HPP Kalivaç**	
	35 years	**60 years**	**35 years**	**60 years**	**35 years**	**60 years**
Externalities (location-specific)						
(10) Cost of new road section	3.08	3.08	0.00	0.00	5.65	5.65
(12) Reservoir-related GHG	0.46	0.46	0.60	0.60	0.34	0.34
(13.1) Foregone value added: agriculture	42.46	42.43	53.12	53.08	33.57	33.55
(13.2) Foregone tax revenues: agriculture	6.37	6.36	7.97	7.96	5.04	5.03
(13.3) Foregone discretionary spending: agriculture employment	0.95	0.95	1.19	1.19	0.75	0.75
(14.1) Foregone value added: tourism	0.98	0.98	0.98	0.99	0.98	0.99
(14.2) Foregone tax revenues: tourism	0.25	0.51	0.25	0.51	0.25	0.51
(14.3) Foregone discretionary spending: tourism employment	0.10	0.10	0.10	0.10	0.10	0.10
Subtotal (C): Value of location-specific externalities	**54.65**	**54.87**	**64.21**	**64.44**	**46.68**	**46.93**
Subtotal (D): Total value of externalities	**53.32**	**53.59**	**62.88**	**63.14**	**45.36**	**45.67**
Subtotal (E): SAVi LCOE	**194.48**	**193.27**	**183.80**	**182.82**	**203.10**	**202.30**

Table C2. **Itemized LCOE (EUR/MWh) of the HPPs over a 60-year lifetime, comparing the effects of the base case with a reduced discount rate case: 13.5% for conventional cost positions and revenues; 6.75% applied to externalities only.**

	HPPs (both), weighted average		HPP Poçem		HPP Kalivaç	
LCOE Categories (EUR/MWh)	**Base case**	**Reduced discount rate**	**Base case**	**Reduced discount rate**	**Base case**	**Reduced discount rate**
Conventional cost positions						
(1) Capital cost	59.31	59.31	64.76	64.76	54.78	54.78
(2) O&M cost*	9.04	9.04	9.87	9.87	8.35	8.35
(3) Concession payments	1.71	1.71	1.89	1.89	1.57	1.57
(4) Corporate taxes	1.74	1.74	1.57	1.57	1.89	1.89
(5) Cost of financing	27.97	27.97	30.54	30.54	26.12	26.12
(6) Compensation payments	1.18	1.18	1.15	1.15	1.21	1.21
(7) Cost of dredging*	38.71	38.71	9.90	9.90	62.72	62.72
Subtotal (A): Conventional LCOE	**139.68**	**139.68**	**119.69**	**119.69**	**156.63**	**156.63**
Externalities						
Externalities (technology-specific)						
(8) Discretionary spending: employment energy capacity	(1.21)	(1.36)	(1.26)	(1.42)	(1.17)	(1.32)
(9) Discretionary spending: employment roads	(0.07)	(0.11)	(0.05)	(0.08)	(0.09)	(0.14)
Subtotal (B): Value of technology-specific externalities	**(1.28)**	**(1.48)**	**(1.31)**	**(1.50)**	**(1.26)**	**(1.46)**

LCOE Categories (EUR/MWh)	HPPs (both), weighted average		HPP Poçem		HPP Kalivaç	
	Base case	Reduced discount rate	Base case	Reduced discount rate	Base case	Reduced discount rate
Externalities (location-specific)						
(10) Cost of new road section	3.08	3.60	0.00	0.00	5.65	6.59
(12) Reservoir-related GHG	0.46	0.97	0.60	1.27	0.34	0.72
(13.1) Foregone value added: agriculture	42.43	88.89	53.08	111.21	33.55	70.29
(13.2) Foregone tax revenues: agriculture	6.36	13.33	7.96	16.68	5.03	10.54
(13.3) Foregone discretionary spending: agriculture employment	0.95	2.05	1.19	2.56	0.75	1.62
(14.1) Foregone value added: tourism	0.98	1.96	0.99	2.24	0.99	2.24
(14.2) Foregone tax revenues: tourism	0.51	1.14	0.51	1.14	0.51	1.14
(14.3) Foregone discretionary spending: tourism employment	0.10	0.22	0.10	0.22	0.10	0.22
Subtotal (C): Value of location-specific externalities	**54.87**	**112.16**	**64.44**	**135.34**	**46.93**	**93.37**
Subtotal (D): Total value of externalities	**53.59**	**110.69**	**63.14**	**133.84**	**45.67**	**91.91**
SAVi LCOE (incl. externalities)	**193.27**	**250.37**	**182.82**	**253.53**	**202.30**	**248.54**

*Note: The LCOE table, in contrast to the CBA tables in Section 4.1, does not distinguish between costs and externalities that occur during and after the concession period for the two HPPs. The LCOE calculation does not account for differences in time when cost and externalities accrue. Cost position (2) captures all O&M costs and cost position (7) captures all cost of dredging over the considered time period. Externality position (11) is hence deliberately not listed in the LCOE table.

Table C3. **Climate change impacts (reduction in precipitation) on the itemized LCOE of HPP Poçem and HPP Kalivaç over the 60-year lifetime (EUR/MWh)**

LCOE Categories (EUR/MWh)	**HPPs (both), weighted average**		**HPP Poçem**		**HPP Kalivaç**	
	BAU	**CC impacts**	**BAU**	**CC impacts**	**BAU**	**CC impacts**
Conventional cost positions						
(1) Capital cost	59.31	60.43	64.76	65.98	54.78	55.81
(2) O&M cost*	9.04	9.21	9.87	10.05	8.35	8.50
(3) Concession payments	1.71	1.75	1.89	1.92	1.57	1.60
(4) Corporate taxes	1.74	1.56	1.57	1.40	1.89	1.68
(5) Cost of financing	27.97	28.59	30.54	31.21	26.12	26.40
(6) Compensation payments	1.18	1.18	1.15	1.15	1.21	1.21
(7) Cost of dredging*	38.71	37.61	9.90	9.62	62.72	60.93
Subtotal (A): Conventional LCOE	**139.68**	**140.32**	**119.69**	**121.35**	**156.63**	**156.13**
Externalities						
Externalities (technology-specific)						
(8) Discretionary spending: employment energy capacity	(1.21)	(1.23)	(1.26)	(1.28)	(1.17)	(1.19)
(9) Discretionary spending: employment roads	(0.07)	(0.07)	(0.05)	(0.05)	(0.09)	(0.09)
Subtotal (B): Value of technology-specific externalities	**(1.28)**	**(1.31)**	**(1.31)**	**(1.33)**	**(1.26)**	**(1.28)**

LCOE Categories (EUR/MWh)	HPPs (both), weighted average		HPP Poçem		HPP Kalivaç	
	BAU	CC impacts	BAU	CC impacts	BAU	CC impacts
Externalities (location-specific)						
(10) Cost of new road section	3.08	3.09	0.00	0.00	5.65	5.66
(12) Reservoir-related GHG	0.46	0.47	0.60	0.61	0.34	0.35
(13.1) Foregone value added: agriculture	42.43	43.23	53.08	54.08	33.55	34.18
(13.2) Foregone tax revenues: agriculture	6.36	6.48	7.96	8.11	5.03	5.13
(13.3) Foregone discretionary spending: agriculture employment	0.95	0.97	1.19	1.21	0.75	0.77
(14.1) Foregone value added: tourism	0.98	0.98	0.99	0.99	0.99	0.99
(14.2) Foregone tax revenues: tourism	0.51	0.51	0.51	0.51	0.51	0.51
(14.3) Foregone discretionary spending: tourism employment	0.10	0.10	0.10	0.10	0.10	0.10
Subtotal (C): Value of location-specific externalities	**54.87**	**55.82**	**64.44**	**65.63**	**46.93**	**47.69**
Subtotal (D): Total value of externalities	**53.59**	**54.52**	**63.14**	**64.29**	**45.67**	**46.40**
SAVi LCOE (incl. externalities)	**193.27**	**194.84**	**182.82**	**185.64**	**202.30**	**202.53**

Table C4. **Reverse engineering–effects of different electricity price assumptions on the Project NPV of both HPPs under different cost scenarios: Comparing results of BAU and the CC scenario**

	Project NPV if electricity price EUR 55/MWh		Project NPV if electricity price EUR 78.47/MWh		Project NPV if electricity price EUR 108.39/MWh	
Scenario	**BAU**	**CC impacts**	**BAU**	**CC impacts**	**BAU**	**CC impacts**
Baseline: Conventional results	(79.85)	(85.80)	0.00	(7.69)	101.77	91.85
Baseline + cost of dredging	(181.62)	(187.36)	(101.77)	(109.25)	0.00	(9.71)
Baseline + technology-specific externalities	(79.04)	(84.94)	0.81	(6.84)	102.58	92.71
Baseline + location-specific externalities	(262.16)	(280.45)	(173.48)	(190.79)	(71.72)	(91.24)
Baseline + all externalities	(261.20)	(279.44)	(172.67)	(189.93)	(70.90)	(90.39)

Table C5. **Reverse engineering–effects of different electricity price assumptions on the Project IRR of both HPPs under different cost scenarios: Comparing results of BAU and the CC scenario**

	Project IRR if electricity price EUR 55/MWh		Project IRR if electricity price EUR 78.47/MWh		Project IRR if electricity price EUR 108.39/MWh	
Scenario	**BAU**	**CC impacts**	**BAU**	**CC impacts**	**BAU**	**CC impacts**
Baseline: Conventional results	9.32%	8.47%	13.50%	13.08%	18.53%	18.30%
Baseline + cost of dredging	3.15%	0.43%	8.10%	6.92%	13.50%	12.96%
Baseline + technology-specific externalities	9.36%	8.53%	13.54%	13.12%	18.56%	18.35%
Baseline + location-specific externalities	0.00%	0.00%	3.71%	0.01%	9.75%	8.11%
Baseline + all externalities	0.00%	0.00%	3.77%	0.10%	9.79%	8.16%

SAVi Sustainable Asset Valuation

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