Basic Conceptual Structure for the Assessment of the Natural Services Provided by Hydroelectricity Projects

Authors:

Enrique Rosales-Asensio, Iker de Loma-Osorio, Noemí González-Cobos, Antonio Pulido-Alonso, David Borge-Diez

Date Submitted: 2023-02-21

Keywords: conceptual structure, natural services, hydroelectricity projects, ecosystem valuation

Abstract:

> This paper presents and defines a method for standardizing ecosystem services in the context of hydropower projects and demonstrates its applicability through the Folsom hydropower plant in California. In particular, this paper uses the Final Ecosystem Goods and Services Classification System (FEGS-CS) to provide a structured framework for identifying ecosystems, the potential services they provide, and their beneficiaries. In this paper, the benefit transfer technique is used for estimating non-market values for new policy contexts. The total value of this case study is about USD 169 million per year for the Folsom hydropower plant in California. The advantage of the proposed framework lies in its ability to be imported and applied to any other hydropower facility, and it can be extensively used both for new and existing power plants.

Record Type: Published Article

Submitted To: LAPSE (Living Archive for Process Systems Engineering)

Citation (overall record, always the latest version):	LAPSE:2023.0795
Citation (this specific file, latest version):	LAPSE:2023.0795-1
Citation (this specific file, this version):	LAPSE:2023.0795-1v1

DOI of Published Version: https://doi.org/10.3390/pr10112267

License: Creative Commons Attribution 4.0 International (CC BY 4.0)

processes

Communication

Basic Conceptual Structure for the Assessment of the Natural Services Provided by Hydroelectricity Projects

Enrique Rosales-Asensio [1,*], Iker de Loma-Osorio [2], Noemí González-Cobos [3], Antonio Pulido-Alonso [1] and David Borge-Diez [2]

[1] Department of Electrical Engineering, University of Las Palmas de Gran Canaria, 35017 Las Palmas de Gran Canaria, Spain
[2] Department of Electrical, Systems and Automation Engineering, University of León, Campus de Vegazana, 24071 León, Spain
[3] Energy Technology Institute (ITE), 46980 Paterna, Spain
* Correspondence: enrique.rosales@ulpgc.es

Abstract: This paper presents and defines a method for standardizing ecosystem services in the context of hydropower projects and demonstrates its applicability through the Folsom hydropower plant in California. In particular, this paper uses the Final Ecosystem Goods and Services Classification System (FEGS-CS) to provide a structured framework for identifying ecosystems, the potential services they provide, and their beneficiaries. In this paper, the benefit transfer technique is used for estimating non-market values for new policy contexts. The total value of this case study is about USD 169 million per year for the Folsom hydropower plant in California. The advantage of the proposed framework lies in its ability to be imported and applied to any other hydropower facility, and it can be extensively used both for new and existing power plants.

Keywords: conceptual structure; natural services; hydroelectricity projects; ecosystem valuation

check for updates

Citation: Rosales-Asensio, E.; Loma-Osorio, I.d.; González-Cobos, N.; Pulido-Alonso, A.; Borge-Diez, D. Basic Conceptual Structure for the Assessment of the Natural Services Provided by Hydroelectricity Projects. *Processes* **2022**, *10*, 2267. https://doi.org/10.3390/pr10112267

Academic Editor: Anna Trubetskaya

Received: 9 October 2022
Accepted: 1 November 2022
Published: 2 November 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

In many modern societies, valuation processes are carried out through monetary measurement [1]. As a consequence, it is usual that those elements considered to be less tangible are omitted from the reference frameworks traditionally used for ecosystem valuation [1]. Considering this approach, when the true value of ecosystem services is included, the valuation resulting from the use of traditional reference frameworks may become unacceptable [2]. Many services provided by ecosystems are not traded in markets and cannot easily be accounted and, as a consequence, many of them have no price assigned to them [3]. The limitations of monetary valuation are especially important when ecosystem change is irreversible or only reversible at prohibitive cost [4].

The services provided by ecosystems were not evaluated from an ecological and economic perspective until the 1960s [5]. That said, it was not until the 1990s that an international reference framework to evaluate such services was proposed [6]. In fact, it was precisely the proposal of such frameworks that led to greater acceptance of these services by the scientific community [6]. In their 1997 study, Costanza et al. presented for the first time a monetary valuation of all of the Earth's ecosystems [7]. The value of the services provided by ecosystems globally was estimated at about USD 33 trillion per year (considering 1995 USD) [7]. This figure was significantly higher than the global gross domestic product (GDP) at the time and, therefore, depicts the lack of a consistent method to evaluate the whole value [8]. The results presented in that research article [8] had a great impact and were widely cited by scientists and environmentalists [9]. However, most economists have been suspicious about it, both conceptually and methodologically [9] because, in essence, it would be a "serious underestimate of infinity" [10].

Although the monetary valuation of ecosystems has been used since the 1960s, such studies increased considerably in the 1990s [11]. This change was due to the fact that a growing number of scientists recognized the attractiveness for policy makers of assigning an economic value to ecological problems [11]. Particularized to the case of ecosystem services, reference frameworks are tools capable of illustrating the trade-offs inherent in stakeholder decision making [12] and of calculating the change in the value of such services between alternative scenarios and their related impacts [13]. There is a general drawback of the monetary valuation method that is that some people may oppose its use on ethical grounds by, for example, considering it inappropriate to assign a monetary value to human life or biodiversity [14].

On the other hand, it should be mentioned that there is an undervaluation of the contributions of ecosystem services [11]. This is partly explained by the fact that such systems are not adequately quantified in terms comparable to other "classical" services or to manufactured capital [11]. While it is recognized that it will be a long-term challenge to account for all impacts related to ecosystem services [3], the valuation of such services is a valuable tool for economic analysis and should not be discarded because of disagreements with certain economists' assumptions about sustainability, fairness, and efficiency [15]. In general, the multicriteria analysis method has been recognized as a useful tool for the evaluation of environmental services [16].

Despite the difficulties involved in transferring approaches and results between different regions of the world [17], benefit transfer can be a practical and inexpensive way to obtain an estimate of the value of local ecosystems, especially when the objective is to assess a large number of diverse ecosystems [17]. Further, benefit transfer may be appropriate when the good or service to be valued has not yet been created (e.g., a proposal to create a new national park–nature–tourism destination), and there are no actual users to survey [18]. Benefit transfer is not a methodology per se but refers to the use of estimates obtained using any current method in one context to estimate values in a different context [18].

Existing models for valuing ecosystem services usually suffer from a lack of replicability in different locations (portability) because quite often a modeling framework developed for one location cannot be imported and applied to another. This aspect limits the replicability of previous research and difficult incremental research. Moreover, benefit estimates are often fragmentary, incomplete, and not comparable with heterogeneous metrics, making it impossible to arrive at a comprehensive assessment. For the particular context of hydropower, the cost/benefit ratio analysis is often incomplete because non-commercial benefits are excluded and, as a consequence, hydropower projects lack standard methodology that considers all aspects to evaluate the global impact of hydro energy. At present, there is no approach that allows for consistent and standardized hydropower benefit and cost analyses. To improve knowledge of the services provided by ecosystems, this article proposes a flexible approach that, even with limited economic resources, is able to reflect the characteristics of the site [19–22] and to value the ecosystem goods and services associated with hydropower projects. For this purpose, the paper presented here will use the procedure known as "benefit transfer" [23].

This first section briefly introduced the concept of ecosystem hydropower services; in the second section, the theoretical background of the communication paper will be shown; in the third section, an economic and environmental assessment will be presented and discussed; finally, in the fourth section, conclusions will be presented.

2. Theoretical Background

Although initially praised and considered a green and clean energy [24], since the 1960s, the development of hydropower became controversial due to its widespread environmental impact [25,26]. However, hydropower has recently received favorable consideration due to its potential to mitigate climate change [27]. The potential benefits of hydropower (improved grid reliability and resilience, economic development, energy independence, and flexibility [28,29]) are real, but are too often overlooked in the assumptions used by planners, investors, and researchers when evaluating hydropower-related projects [30]. In fact, hydropower development brings not only economic benefits but also a wide range of environmental, social, and recreational effects [29,31]. As a consequence of the above, the development of a framework capable of assessing such benefits is necessary and is likely to mobilize additional sources of funding to support their adoption [32].

In the scientific literature, it is possible to find a large number of research papers exploring how to value services provided by hydroelectric energy generation. Among the most notable are those carried out by Yang et al., who established a non-monetary accounting framework for ecosystem service valuation [33]; Wang et al., who proposed a framework to evaluate and valuate the effects on watershed ecosystem services caused by hydropower development [34]; Liang et al., who proposed a framework of the ecological benefit–loss evaluation for hydropower projects [35]; Mishra et al., who, in order to quantify the effect of climate changes on hydropower and fisheries, developed a framework that links biophysical models and economic models [36]; and the investigation conducted by Amjath-Babu, who constructed a hydro-economic model by soft coupling hydrological and crop growth simulation models to an economic optimization model [37].

However, the development of a comprehensive framework that categorizes all associated ecosystem services through a metric capable of assigning a price to these services has not been given the same attention, so a study that addresses this is necessary. From a deep survey of the gray literature and updated literature related to the topic addressed here [38–43], it was possible to find that even though there are many different approaches, this paper contributes to the pool of existing knowledge proposing an approach to evaluate the whole scope of hydropower energy.

Final Ecosystem Goods and Services (FEGS) are a way to include and measure the benefits associated with natural ecosystems [44] while providing a means to standardize their classification [45]. FEGS represent ecosystems in terms of the goods or services they produce [46] and are useful for communicating to stakeholders and policy makers how people derive specific benefits from ecosystems [47]. Yee et al. [48] applied the concept of final ecosystem goods and services to review the broad suite of ecosystem services and their beneficiaries relevant to the management of two federal programs for estuary management. Following [48], this paper uses the Final Ecosystem Goods and Services Classification System (FEGS-CS) to provide a structured framework for identifying ecosystems, the potential services they provide, and their beneficiaries.

For the identification of services associated with ecosystems, this article uses, in addition to the Final Ecosystem Goods and Services (FEGS) [45], a list derived from a gray literature review [49–53] and research articles [54]. Table 1 presents a matrix summary of the final ecosystem goods and services identified for each environmental sub-class. For the preparation of Table 1, it was necessary to take into account three main aspects:

1. the environmental engineering literature to identify the most significant impacts associated with the construction and operation of hydropower projects,
2. the environmental economics literature to identify the economic benefits of such projects, as well as
3. the Final Ecosystem Goods and Services, other gray literature, and research articles in order to associate the services provided by ecosystems with their respective beneficiaries.

The interaction between the four drivers contributing to human well-being: (i) social capital, (ii) built capital, (iii) human capital, and (iv) natural capital, and contributing to social and human well-being is shown in Figure 1. These elements constitute the well-known "four capitals" and are intertwined to build a robust economy and promote people's well-being [55]. Any study valuing a hydropower project can refer to the summary matrix of identified ecosystem goods and services, a general description of the beneficiary, and the importance of those goods and services to the beneficiary. The whole scope of benefits can be evaluated using the evaluation matrix A (Table 1). In short, the evaluation matrix A (matrix of identified ecosystem goods and services to value a specific hydropower project) can be easily adapted to a specific case study and therefore represents an approach for these projects.

Table 1. Matrix A: The description and importance of beneficiary categories and subcategories. Source: Information selected and transcribed from the U.S. EPA. Final Ecosystem Goods and Services Classification System (FEGS-CS) [45].

Beneficiary Categories and Sub-Categories	General Beneficiary Description	Ecosystem Goods and Services	Importance to the Beneficiary
AGRICULTURAL			
Irrigators	*Irrigators interact with aquatic environments, as they consume water from aquatic environments for maintaining crops, often moving water through ditches and canals. Note that farmers and irrigators are different beneficiaries*	*Water*	*Water for growing and maintaining crops*
Concentrated animal feeding operation Operators	*This beneficiary raises large, dense populations of livestock in a confined area (whether indoors or outdoors)*	*Water*	*Water for livestock consumption*
Livestock Grazers	*This beneficiary uses the environment to graze livestock. Cultivated vegetation is NOT considered an ecosystem good and service. For agroecosystems, "planted" pastures only provide space and opportunity to grow feed (not the vegetation itself).*	• *Water* • *Flora*	• *Water suitable for livestock consumption* • *Non-cultivated vegetation for livestock consumption*
COMMERCIAL/INDUSTRIAL			
Electric and other Energy Generators	*This beneficiary relies on the environment for the energy or placement of power generation structures, including dams, wind, water, or wave turbines, solar panels, geothermal systems, etc.*	• *The presence of the environment* • *Water*	• *Opportunity to install power generation structures, such as dams and water turbines* • *Flowing water that can be used for energy generation*
GOVERNMENT, MUNICIPAL, AND RESIDENTIAL			
Municipal Drinking Water Plant Operators	*This beneficiary is responsible for providing water to a community and may do so by collecting water from rivers, reservoirs, lakes, wells, bays, or estuaries. Water is treated and distributed. Direct precipitation is not generally used as a water source.*	*Water*	*Water suitable for processing by a municipal drinking water plant*
Waste Water Treatment Plant Operators	*This beneficiary uses the environment [only] for discharging treated water*	*Water*	*Medium for discharging [treated municipal wastewater] into the environment*
Residential Property Owners	*While changes in property value are not an FEGS, residential property owners are affected by the environment in which their property resides.*	*The presence of the environment*	*Opportunity for the placement of infrastructure and reduced/increased risk of flooding, erosion, and pest infestation on the property*
Military/Coast Guard	*The Military/Coast Guard relies on the environment for the placement of infrastructure (e.g., ports, bases, etc.) or conditions for training activities*	• *The presence of the environment* • *Open space*	• *Opportunity for the placement of infrastructure* • *Suitable conditions for training activities*
COMMERCIAL/MILITARY TRANSPORTATION			
Transporters of Goods	*This beneficiary uses the environment as a medium to transport goods—specifically, via boats (e.g., barges), airplanes, and overland/off-road vehicles (e.g., quads).*	• *The presence of the environment* • *Water*	• *Opportunity for the transportation of goods* • *Medium for and conditions that support the transportation of goods*

Table 1. *Cont.*

Beneficiary Categories and Sub-Categories	General Beneficiary Description	Ecosystem Goods and Services	Importance to the Beneficiary
Transporters of People	*This beneficiary uses the environment as a medium to transport people—specifically,* via *boats (e.g., cruise liners, ferries, tour boats), airplanes, and overland/offroad vehicles.*	• *The presence of the environment* • *water*	• *Opportunity for the transportation of people* • *Medium for and conditions that support the transportation of people*
SUBSISTENCE			
Water Subsisters	*Water subsisters rely on a natural source for drinking water and may use wells or cisterns for storage (i.e., they do not receive municipal drinking water). Water purity is important, as water is not or only minimally treated.*	*Water*	*Water suitable for drinking (i.e., human consumption)*
Food Subsisters	*Food subsisters use the natural abundance of [edible] flora, fungi, and fauna whether collecting, hunting, or fishing as a major supplement to their existence.*	• *Flora* • *Fauna*	• *Edible organisms (i.e., flowers, plants, etc.) or associated products (i.e., fruit, greens, tubers, berries, sap) that are gathered for personal use (i.e., not for sale)* • *Edible organisms (i.e., birds, mammals, reptiles, etc.) that are hunted for personal use (i.e., not for sale)*
Timber, Fiber, and Fur/Hide Subsisters	*This beneficiary relies on the natural abundance of timber, fiber, and [fauna for] fur/hide for survival. Timber, fiber, and fur/hide used for building material are accounted for in this category*	• *Fiber* • *Fauna*	• *Fiber used for clothing/warmth, infrastructure, housing, roofing, and/or fuel for personal use (i.e., not for sale)* • *Organisms (i.e., mammals and reptiles) that provide fur or hides used for clothing/warmth, infrastructure, housing, roofing, and/or fuel for personal use (i.e., not for sale)*
RECREATIONAL			
Waders, Swimmers, and Divers	*This beneficiary recreates in or under the water by either wading, swimming, or diving (i.e., snorkeling, scuba diving). By definition, this beneficiary has contact with water.*	*Presence of the environment*	*Opportunity and conditions for wading, swimming, and/or diving*
Experiencers and Viewers	*This beneficiary views and experiences the environment* via *an activity, such as scenery gazing, hiking, bird watching, botanizing, ice skating, rock climbing, flying kites,* etc. *This beneficiary does not have physical contact with water.*	• *The presence of the environment* • *Viewscapes* • *Flora* • *Fauna* • *Fungi* • *Sounds and scents*	• *Opportunity to view the environment and organisms within it* • *Landscape that provides a sensory experience* • *Organisms (i.e., flowers, plants, etc.) that can be viewed* • *Organisms (i.e., birds, mammals, reptiles, etc.) that can be viewed* • *Organisms (i.e., mushrooms, shelf fungus, puffballs, etc.) that can be viewed* • *Sounds and scents that provide a sensory experience*

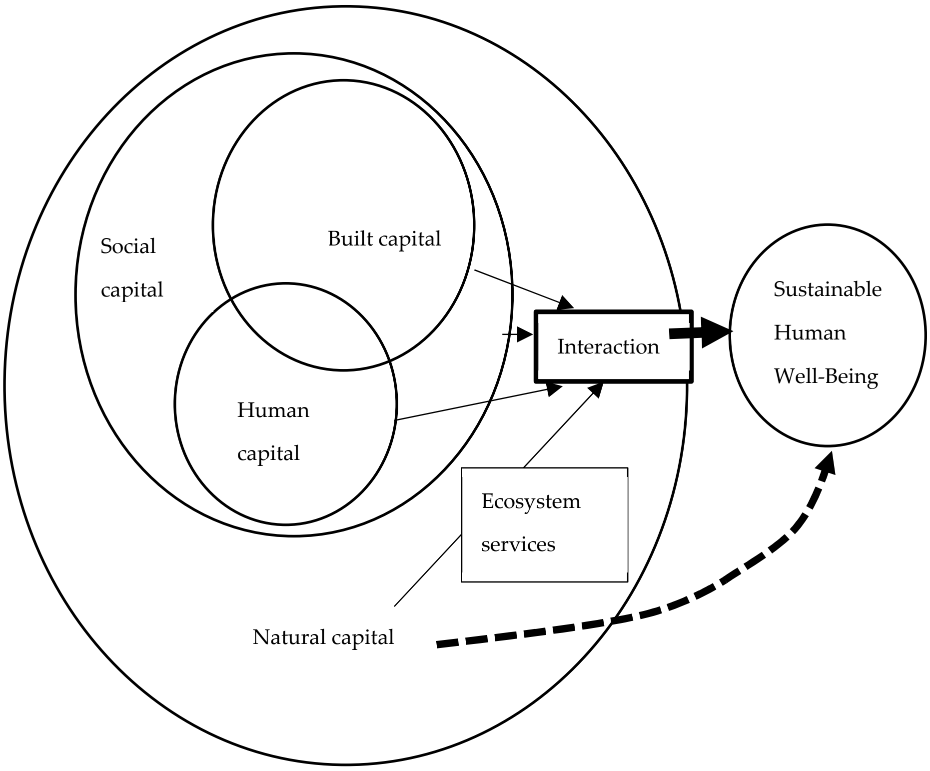

Figure 1. Interaction between social capital, built capital, human capital, and natural capital to contribute to social and human well-being. Source: Adapted from [56].

3. Economic and Environmental Assessment

This section analyzes how to use the matrix of identified ecosystem goods and services to value a specific hydropower project, particularizing it to the case of Folsom Dam. Folsom Dam is a major water management facility located in a large metropolitan area [57] located about 40 km northeast of Sacramento [58]. Although its primary function is flood control, Folsom Dam stores water for irrigation, domestic use, and electric power generation [58]. On the other hand, Folsom Dam equally offers opportunities for hiking, biking, camping, horseback riding, water skiing, and boating [59]. Folsom Dam was chosen as a case study for this article because of the high amount of publicly available data. Given the inability to conduct specific surveys, recording costs and benefits associated with the project, this article relied on the next best available option (public data) to demonstrate the efficacy of the proposed framework. Of all the sites that had been shortlisted to demonstrate the proposed framework, Folsom Dam was selected due to, among other reasons, the availability of local recreational use surveys by activity type (hiking, biking, camping, horseback riding, water skiing, and boating) and the public dissemination of the results obtained.

These publicly available data allowed us to demonstrate the effectiveness of the proposed framework using site-specific data without resorting to new surveys or data collection. Data on Folsom Dam, water released for flood control, number of visitors, and its associated activities were obtained primarily from public information available through the California State Parks [60–64] and the Central Valley Flood Protection Board [65]. Although originally authorized in 1944 as a flood control unit, Folsom Dam was converted in 1949 to a multipurpose facility of about 1.25 million cubic kilometers [66]. Energy prices were obtained from the Energy Information and Administration "Wholesale Electricity and Natural Gas Market Data" [67] (using data from the California Independent System Operator CAISO SP15 EZ) and the amount of energy produced from information available from the Global Energy Observatory [68].

Table 2 presents a matrix summary of beneficiary categories, beneficiary sub-categories, and ecosystem goods and services. It should be noted that the information contained in matrix B may serve as a model for other valuations to demonstrate that as many types of benefits as possible should be taken into account and, therefore, presents a general framework to evaluate these projects.

Table 2. Matrix B: matrix summary of beneficiary categories, beneficiary sub-categories, and ecosystem goods and services. Source: Adapted from the U.S. EPA. Final Ecosystem Goods and Services Classification System (FEGS-CS) [45].

Beneficiary Category	Beneficiary Sub-Category	Water	Flora	Presence of the Environment	Open Space	Fauna	Fiber	Viewscapes	Fungi	Sounds and Scents
AGRICULTURAL										
	Irrigators	X								
	Concentrated animal feeding operation Operators	X								
	Livestock Grazers	X	X							
COMMERCIAL/INDUSTRIAL										
	Electric and other Energy Generators	X		X						
GOVERNMENT, MUNICIPAL, AND RESIDENTIAL										
	Municipal Drinking Water Plant Operators	X								
	Waste Water Treatment Plant Operators	X								
	Residential Property Owners			X						
	Military/Coast Guard			X	X					
COMMERCIAL/MILITARY TRANSPORTATION										
	Transporters of Goods	X		X						
	Transporters of People	X		X						
SUBSISTENCE										
	Water Subsisters	X								
	Food Subsisters		X			X				
	Timber, Fiber, and Fur/Hide Subsisters					X	X			
RECREATIONAL										
	Waders, Swimmers, and Divers			X						
	Experiencers and Viewers		X	X		X		X	X	X

To fully understand the relationship between matrix A and matrix B (Tables 1 and 2), it should be mentioned that beneficiary categories and their associated subcategories (Table 1, matrix A) are to be considered as the interests of an individual (i.e., person, organization, household, or firm) that drive active or passive consumption and/or appreciation of ecosystem services resulting in an impact (positive or negative) on their welfare. The fundamental goal in developing matrix B (Table 2) was, taking into account beneficiary categories and their associated subcategories provided in Table 1, to organize ecosystem services in a consistent and meaningful manner that pertains explicitly to both the landscape and specific beneficiaries. Selected ecosystem goods and services from Table 2 (water; flora; presence of the environment; open space; fauna; fiber; viewscapes; fungi; sounds and scents) are innately associated with the environment in which they occur and to the beneficiary that utilizes them.

To properly evaluate the impact associated with the Folsom hydroelectric power plant project using the benefit transfer technique, beneficiary categories and sub-categories presented in matrix A and B (selected from the U.S. EPA. Final Ecosystem Goods and Services Classification System FEGS-CS) are to be "translated" into an asset category and an asset type that could be easily evaluated through a unit value and its amount. To conduct this, Table 3 is presented. This "translation" from beneficiary categories and sub-categories into asset categories and asset types effectively offers an approach that allows a uniform and standardized analysis of the costs and benefits of hydropower projects. Benefit transfer is a technique that can be used to apply existing value estimates to new contexts [69] in a relatively easy and inexpensive way if used appropriately [70]. Most of the valuation approaches shown in Table 3 can be applied using the benefit transfer technique. Table 3 presents a list of elements, ecosystem and economic metrics, and valuation approaches considered in the assessment. The valuation of goods and services that are not directly defined by market prices (i.e., their value through revealed preference methods or hypothetical markets) could likewise be added to the evaluation and, in particular, Table 3 shows the data used to assess the impact associated with the Folsom hydroelectric plant project. For this purpose, this impact has been divided into three main elements, namely, "Energy", "Externalities", and "Recreation".

Table 3. Data used to assess the impact associated with the Folsom hydroelectric power plant project.

Asset Category	Asset Type	Unit Value	Amount	Benefit Value
Energy	Electricity generation	56.90 USD/MWh * [67]	691,358 MWh [68,71]	USD 39,338,270
Externalities	Rate to rent cropland	−133.95 USD/ha [72]	4830 ha [58,73]	USD −646,983
	Emissions	50 USD/ton CO_2 [74]	28,806 tons CO_2 [75]	USD −1,440,300
	Municipal and industrial water use	100 hm^3 [65,76]	0.33 $/$m^3$ [77–79]	33,000,000
	Agricultural water use	516 hm^3 [65,76]	0.066 USD/m^3 [76,77,80]	USD 34,056,000
Recreation	Day use	USD 12 [81]	2,500,000 [60–65,82]	USD 30,000,000
	Camping fees	USD 33 [81]	640,000 [60–65,82]	USD 21,120,000
	Boat Launching—Power Boat	USD 10 [81]	1,332,500 [60–65,82]	USD 13,325,000
TOTAL				**USD 168,661,987**

* Average value of the wholesale price during the year 2021 for the California Independent System Operator CAISO SP15 EZ.

The generators at the Folsom power plant were built in 1956 [83] and have a combined capacity of 198 megawatts [68,83]. On average, the plant produces about 10% of the power used in Sacramento each year [83]. Since the 1950s, more than 90% of hydroelectric power plants have been developed under conditions where revenue security was provided through power purchase guarantees or long-term contracts [84]. Today, in competitive areas, hydropower generators produce electricity that will be sold on the wholesale market [85]. In the paper presented here, it will be assumed that the value associated with the generated energy is the revenue received from the sale of energy in the wholesale market. The ultimate purpose of the "Rate to Rent Cropland" externality is to assess the impact resulting from the flooding of land that, had the Folsom Reservoir not been built, would have been used on farms. This externality is evaluated in dollars per hectare, using information available from the California Department of Parks and Recreation [58] and the U.S. Department of Agriculture [72].

CO_2 emissions are calculated as a precursor externality to global warming [86]. Emissions related to the construction and operation of a hydroelectric power plant vary depending on its type, size, and location [75]. With the use of the estimated average intensity of greenhouse gas emissions associated with hydropower [75] and the social cost of carbon dioxide emissions [74], the externality resulting from CO_2 emissions has been calculated.

The dam also provides usable water for municipal, industrial, and agricultural uses. The amount of water withdrawn is provided in cubic hectometers, using information provided by the Central Valley Flood Protection Board [65] and the U.S. Department of the Interior Bureau of Reclamation Mid-Pacific Region [76]. The agricultural water value was obtained from the U.S. Department of the Interior Bureau of Reclamation Mid-Pacific Region [76] and the San Juan Water District [77]. Following [65,76], about 100 hm^3 are withdrawn annually from Folsom Dam for municipal and industrial water use. Assuming a municipal water cost of USD 0.33/m^3 before treatment and distribution (i.e., the value at the source) [77–79], the resulting benefits from this concept would amount to USD 33,000,000. One of the main revenues resulting from the operation of the Folsom Reservoir hydroelectric project is the benefits associated with its recreational supply. The Folsom Dam area has about 2,500,000 visitors per year who come for swimming, boating, hiking, camping, etc. [60–65,82]. The construction of this reservoir provides a variety of recreational activities that would not be available without it. The number of visitors participating in each activity is combined with park fees provided by the California Department of Parks and Recreation [81] to obtain the total value of recreational activities.

The sum of all of the values listed above gives us the total economic value of this dam. This value can be compared to the construction cost of the dam to determine if the project is economically viable. The total value of this case study is about USD 169 million per year. The largest percentages come from water use, recreation, and electricity generation. It is also possible to use these values to conduct a stakeholder-specific cost–benefit analysis. The economic values can be separated by stakeholder, and these values can be used to determine whether the project is economically viable. From a public policy standpoint, it is valuable to evaluate the positive and negative impacts of activities and to obtain an instructive comparison of benefits and costs [87]. In the case of hydropower projects, this can be done through a cost–benefit analysis for each stakeholder using a framework similar to the one proposed in this paper.

4. Conclusions

Despite the extensive development of hydropower energy worldwide, the existing models for valuing ecosystem services lack the required replicability in different locations (portability), and often a modeling framework developed for one location cannot be applied to another. This aspect is a limitation for the replicability of previous research, as benefit estimates are often incomplete and not comparable. This paper evaluated the particular context of hydropower, a sector in which cost/benefit ratio analysis is often incomplete because non-commercial benefits are excluded due to the lack of standard methodology that considers all aspects to evaluate the global impact of hydro energy. This paper proposes a framework for the valuation of hydropower projects that can be applied to any site as long as its specific characteristics are taken into account. In particular, this paper demonstrates the applicability of the methodology through the Folsom hydropower plant in California, for which ecosystem services are valued as USD 168,661,987/year. The main limitation of the proposed approach is the large amount of data required, as to properly assess each type of benefit, publicly available data are necessary. The proposed valuation framework is particularly advantageous for those assessments that do not have the necessary funding to determine all of the benefits associated with the hydropower project in situ. Despite these limitations, the proposed approach to valuing hydropower projects enables energy policy analysis while providing insight into the distributional consequences at the individual stakeholder level and can be extensively used both for new and existing power plants.

Author Contributions: E.R.-A.: conceptualization, methodology, formal analysis, data curation, writing—original draft preparation, and funding acquisition; I.d.L.-O.: formal analysis, data curation, writing—original draft preparation, and writing—review and editing; N.G.-C.: visualization and supervision; A.P.-A.: visualization and supervision; D.B.-D.: visualization, supervision, project administration. All authors have read and agreed to the published version of the manuscript.

Funding: This paper received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors gratefully acknowledge the support of the Center for Industrial Technological Development (CDTI) through its “Proyectos Transferencia Cervera” research program, without which the present study could not have been completed. This work has been supported by the Center for Industrial Technological Development, Spain (Project HysGrid+ “Desarrollo de Comunidades Locales Energéticamente Positivas con Sistemas Híbridos de Generación Renovable y Almacenamiento”, CER20191019).

Conflicts of Interest: The authors declare no conflict of interest.

Nomenclature

CAISO	California Independent System Operator
CO_2	Carbon dioxide
FEGS	Final Ecosystem Goods and Services
GDP	Gross domestic product

References

1. Small, N.; Munday, M.; Durance, I. The challenge of valuing ecosystem services that have no material benefits. *Glob. Environ. Change* **2017**, *44*, 57–67. [CrossRef]
2. TEEB. *The Economics of Ecosystems and Biodiversity in National and International Policy Making*; ten Brink, P., Ed.; Earthscan: London, UK; Washington, DC, USA, 2011.
3. DEFRA. *An Introductory Guide to Valuing Ecosystem Services*; Defra—Department for Environment Food and Rural Affairs: London, UK, 2007.
4. Azadi, H.; Passel, S.V.; Cools, J. Rapid economic valuation of ecosystem services in man and biosphere reserves in Africa: A review. *Glob. Ecol. Conserv.* **2021**, *28*, e01697. [CrossRef]
5. Bagstad, K.J.; Johnson, G.W.; Voigt, B.; Villa, F. Spatial dynamics of ecosystem service flows: A comprehensive approach to quantifying actual services. *Ecosyst. Serv.* **2013**, *4*, 117–125. [CrossRef]
6. De Luca Peña, L.V.; Taelman, S.E.; Préat, N.; Boone, L.; Van der Biest, K.; Custódio, M.; Lucas, S.H.; Everaert, G.; Dewulf, J. Towards a comprehensive sustainability methodology to assess anthropogenic impacts on ecosystems: Review of the integration of Life Cycle Assessment, Environmental Risk Assessment and Ecosystem Services Assessment. *Sci. Total Environ.* **2022**, *808*, 152125. [CrossRef] [PubMed]
7. Costanza, R.; d’Arge, R.; de Groot, R.; Farber, S.; Grasso, M.; Hannon, B.; Limburg, K.; Naeem, S.; Paruelo, J.; Raskin, R.G.; et al. The Value of the World’s Ecosystem Services and Natural Capital. *Nature* **1997**, *387*, 253–260. [CrossRef]
8. Costanza, R.; de Groot, R.; Sutton, P.; van der Ploeg, S.; Anderson, S.J.; Kubiszewski, I.; Farber, S.; Turner, R.K. Changes in the global value of ecosystem services. *Glob. Environ. Change* **2014**, *26*, 152–158. [CrossRef]
9. Pagiola, S.; von Ritter, K.; Bishop, J. *Assessing the Economic Value of Ecosystem Conservation*; Environment Department Paper No. 101; The World Bank: Washington, DC, USA, 2004.

10. Toman, M.A. Why not calculate the value of the world's ecosystem services and natural capital? *Ecol. Econ.* **1998**, *25*, 57–60. [CrossRef]
11. Braat, L.C.; de Groot, R. The ecosystem services agenda: Bridging the worlds of natural science and economics, conservation and development, and public and private policy. *Ecosyst. Serv.* **2012**, *1*, 4–15. [CrossRef]
12. Cavender-Bares, J.; Polasky, S.; King, E.; Balvanera, P. A sustainability framework for assessing trade-offs in ecosystem services. *Ecol. Soc.* **2015**, *20*, 17. [CrossRef]
13. WBCSD. *Guide to Corporate Ecosystem Valuation: A Framework for Improving Corporate Decision-Making*; World Business Council for Sustainable Development: Geneva, Switzerland, 2011.
14. Ludwig, D. Limitations of Economic Valuation of Ecosystems. *Ecosystems* **2000**, *3*, 31–35. [CrossRef]
15. Farley, J. Ecosystem services: The economics debate. *Ecosyst. Serv.* **2012**, *1*, 40–49. [CrossRef]
16. Brzoska, P.; Grunewald, K.; Bastian, O. A multi-criteria analytical method to assess ecosystem services at urban site level, exemplified by two German city districts. *Ecosyst. Serv.* **2021**, *49*, 101268. [CrossRef]
17. Pascual, U.; Muradian, R.; Brander, L.; Gómez-Baggetun, E.; Martín-López, B.; Verma, M.; Armsworth, P.; Christie, M.; Cornelissen, H.; Eppink, F.; et al. The economics of valuing ecosystem services and biodiversity. In *The Economics of Ecosystems and Biodiversity (TEEB) Ecological and Economic Foundations*; Kumar, P.E., Ed.; Earthscan: London, UK, 2010; Chapter 5; pp. 183–256.
18. Dixon, J.A. *Implementation Guideline: Economic Cost-Benefit Analysis (CBA) of Project Environmental Impacts and Mitigation Measures for Waste Water Treatment Projects (WWTPS)*; Inter-American Development Bank: Washington, DC, USA, 2012.
19. Pandeya, B.; Buytaert, W.; Zulkafli, Z.; Karpouzoglou, T.; Mao, F.; Hannah, D.M. A comparative analysis of ecosystem services valuation approaches for application at the local scale and in data scarce regions. *Ecosyst. Serv.* **2016**, *22*, 250–259. [CrossRef]
20. De Groot, R.; Brander, L.; Solomonides, S. *Update of Global Ecosystem Service Valuation Database (ESVD)*; FSD Report No 2020-06; Department for Environment, Food and Rural Affairs: London, UK, 2020.
21. Whitehead, J.C.; Morgan, O.A.; Huth, W.L. Benefit Transfers with the Contingent Valuation Method. In *Benefit Transfer of Environmental and Resource Values*; Springer: Dordrecht, The Netherlands, 2015; pp. 119–140.
22. ELD Initiative. ELD Campus. Module: Valuation of Ecosystem Services. 2019. Available online: https://www.eld-initiative.org/fileadmin/user_upload/Modul_08_Valuation_of_ecosystem_services_191011_www.pdf (accessed on 25 May 2022).
23. Boyle, K.J.; Parmeter, C.F. Benefit Transfer for Ecosystem Services. Oxford Research Encyclopedia of Environmental Science. 26 September 2017. Available online: https://oxfordre.com/environmentalscience/view/10.1093/acrefore/9780199389414.001.0001/acrefore-9780199389414-e-455 (accessed on 24 May 2022).
24. Palmeirim, A.F.; Gibson, L. Impacts of hydropower on the habitat of jaguars and tigers. *Commun. Biol.* **2021**, *4*, 1358. [CrossRef]
25. Auestad, I.; Nilsen, Y.; Rydgren, K. Environmental Restoration in Hydropower Development—Lessons from Norway. *Sustainability* **2018**, *10*, 3358. [CrossRef]
26. EIB. *Environmental, Climate and Social Guidelines on Hydropower Development*; European Investment Bank: Luxembourg, 2019.
27. Gunatilake, H.; Wijayatunga, P.; Roland-Holst, D. *Hydropower Development and Economic Growth in Nepal*; Asian Development Bank: Manila, Philippines, 2020.
28. Veselka, T.D.; Ploussard, Q.; Christian, M. *Historical Hydropower Operations and Economic Value*; Argonne National Laboratory: Lemont, IL, USA, 2020.
29. Office of Energy Efficiency & Renewable Energy. Benefits of Hydropower Water Power Technologies Office; Office of Energy Efficiency & Renewable Energy: Washington, DC, USA. Available online: https://www.energy.gov/eere/water/benefits-hydropower (accessed on 25 May 2022).
30. Sovacool, B.K.; Walter, G. Internationalizing the political economy of hydroelectricity: Security, development and sustainability in hydropower states. *Rev. Int. Polit. Econ.* **2019**, *26*, 49–79. [CrossRef]
31. Nhiakao, K.; Yabar, H.; Mizunoya, T. Cost-Benefit Analysis of the Nam Che 1 Hydropower Plant, Thathom District, Laos: An Ex-Post Analysis. *Sustainability* **2022**, *14*, 3178. [CrossRef]
32. Opperman, J.; Grill, G.; Hartmann, J. *The Power of Rivers: Finding Balance between Energy and Conservation in Hydropower Development*; The Nature Conservancy: Washington, DC, USA, 2015.
33. Yang, Q.; Liu, G.; Casazza, M.; Campbell, E.T.; Giannetti, B.F.; Brown, M.T. Development of a new framework for non-monetary accounting on ecosystem services valuation. *Ecosyst. Serv.* **2018**, *34*, 37–54. [CrossRef]
34. Wang, G.; Fang, Q.; Zhang, L.; Chen, W.; Chen, Z.; Hong, H. Valuing the effects of hydropower development on watershed ecosystem services: Case studies in the Jiulong River Watershed, Fujian Province, China. *Estuar. Coast. Shelf Sci.* **2010**, *86*, 363–368. [CrossRef]
35. Liang, C.; Xin, S.; Dongsheng, W.; Xiuying, Y.; Guodong, J. The ecological benefit–loss evaluation in a riverine wetland for hydropower projects—A case study of Xiaolangdi reservoir in the Yellow River, China. *Ecol. Eng.* **2016**, *96*, 34–44. [CrossRef]
36. Mishra, S.K.; Hayse, J.; Veselka, T.; Yan, E.; Kayastha, R.B.; LaGory, K.; McDonald, K.; Steiner, N. An integrated assessment approach for estimating the economic impacts of climate change on River systems: An application to hydropower and fisheries in a Himalayan River, Trishuli. *Environ. Sci. Policy* **2018**, *87*, 102–111. [CrossRef]
37. Amjath-Babu, T.S.; Sharma, B.; Brouwer, R.; Rasul, G.; Wahid, S.M.; Neupane, N.; Bhattarai, U.; Sieber, S. Integrated modelling of the impacts of hydropower projects on the water-food-energy nexus in a transboundary Himalayan river basin. *Appl. Energy* **2019**, *239*, 494–503. [CrossRef]

38. Fu, B.; Wang, Y.K.; Xu, P.; Yan, K.; Li, M. Value of ecosystem hydropower service and its impact on the payment for ecosystem services. *Sci. Total Environ.* **2014**, *472*, 338–346. [CrossRef]
39. Briones-Hidrovo, A.; Uche, J.; Martínez-Gracia, A. Estimating the hidden ecological costs of hydropower through an ecosystem services balance: A case study from Ecuador. *J. Clean. Prod.* **2019**, *233*, 33–42. [CrossRef]
40. Briones-Hidrovo, A.; Uche, J.; Martínez-Gracia, A. Determining the net environmental performance of hydropower: A new methodological approach by combining life cycle and ecosystem services assessment. *Sci. Total Environ.* **2020**, *712*, 136369. [CrossRef] [PubMed]
41. Barton, D.N.; Sundt, H.; Bustos, A.A.; Fjeldstad, H.P.; Hedger, R.; Forseth, T.; Köhler, B.; Aas, Ø.; Alfredsen, K.; Madsen, A.L. Multi-criteria decision analysis in Bayesian networks—Diagnosing ecosystem service trade-offs in a hydropower regulated river. *Environ. Model. Softw.* **2020**, *124*, 104604. [CrossRef]
42. Vogl, A.L.; Dennedy-Frank, P.J.; Wolny, S.; Johnson, J.A.; Hamel, P.; Narain, U.; Vaidya, A. Managing forest ecosystem services for hydropower production. *Environ. Sci. Policy* **2016**, *61*, 221–229. [CrossRef]
43. Yang, S.; Chen, B. Environmental Impact of Manwan Hydropower Plant on River Ecosystem Service. *Energy Procedia* **2014**, *61*, 2721–2724. [CrossRef]
44. EPA. Final Ecosystem Goods and Services (FEGS) What Are FEGS? Available online: https://www.epa.gov/eco-research/final-ecosystem-goods-and-services-fegs (accessed on 26 May 2022).
45. U.S. EPA. *Final Ecosystem Goods and Services Classification System (FEGS-CS)*; EPA/600/R-13/ORD-004914; U.S. Environmental Protection Agency: Washington, DC, USA, 2013. Available online: https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=515244&Lab=NHEERL (accessed on 25 May 2022).
46. Tashie, A.; Ringold, P. A critical assessment of available ecosystem services data according to the Final Ecosystem Goods and Services framework. *Ecosphere* **2019**, *10*, e02665. [CrossRef]
47. DeWitt, T.H.; Berry, W.J.; Canfield, T.J.; Fulford, R.S.; Harwell, M.C.; Hoffman, J.C.; Johnston, J.M.; Newcomer-Johnson, T.A.; Ringold, P.L.; Russel, M.J.; et al. The Final Ecosystem Goods & Services (FEGS) Approach: A Beneficiary-Centric Method to Support Ecosystem-Based Management. In *Ecosystem-Based Management, Ecosystem Services and Aquatic Biodiversity*; O'Higgins, T., Lago, M., DeWitt, T., Eds.; Springer: Cham, Switzerland, 2020.
48. Yee, S.H.; Sullivan, A.; Williams, K.C.; Winters, K. Who Benefits from National Estuaries? Applying the FEGS Classification System to Identify Ecosystem Services and their Beneficiaries. *Int. J. Environ. Res. Public Health* **2019**, *16*, 2351. [CrossRef]
49. LIFE. Assessing Ecosystems and Their Services in LIFE Projects—A Guide for Beneficiaries. Available online: https://ec.europa.eu/environment/archives/life/toolkit/pmtools/life2014_2020/documents/life_ecosystem_services_guidance.pdf (accessed on 7 June 2022).
50. Neugarten, R.A.; Langhammer, P.F.; Osipova, E.; Bagstad, K.J.; Bhagabati, N.; Butchart, S.H.M.; Dudley, N.; Elliott, V.; Gerber, L.R.; Arrellano, C.G.; et al. *Tools for Measuring, Modelling, and Valuing Ecosystem Services: Guidance for Key Biodiversity Areas, Natural World Heritage Sites, and Protected Areas*; International Union for Conservation of Nature and Natural Resources: Gland, Switzerland, 2018.
51. Parker, N.; Naumann, E.-K.; Medcalf, K.; Haines-Young, R.; Potschin, M.; Kretsch, C.; Parker, J.; Burkhard, B. *National Ecosystem and Ecosystem Service Mapping Pilot for a Suite of Prioritised Services*; Irish Wildlife Manuals, No. 95; National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs: Belfast, Ireland, 2016.
52. Olubode-Awosola, F. *Project Summary Report—Fresh Water Ecosystem Services Project—Phase 1*; Waikato Regional Council: Hamilton, OH, Canada, 2016.
53. Bergstrom, J.C.; Covich, A.P.; Moore, R. Economic Valuation of Ecosystem Services in the Savannah River Basin: Conceptual Study Plan. Available online: https://www.hec.usace.army.mil/sustainablerivers/publications/docs/Savannah%20-%20Ecosystem%20services%20valuation.pdf (accessed on 7 June 2022).
54. Brauman, K.A.; Daily, G.C.; Duarte, T.K.E.; Mooney, H.A. The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services. *Annu. Rev. Environ. Resour.* **2007**, *32*, 67–98. [CrossRef]
55. Batker, D.; Swedeen, P.; Costanza, R.; de la Torre, I.; Boumans, R.; Bagstad, K. *A New View of the Puget Sound Economy: The Economic Value of Nature's Services in the Puget Sound Basin*; Earth Economics: Seattle, WA, USA, 2008.
56. Cramer, G.L.; Paudel, K.P.; Schmitz, A. (Eds.) *The Routledge Handbook of Agricultural Economics*, 1st ed.; Routledge: Abingdon-on-Thames, UK, 2018.
57. Bureau of Reclamation. Folsom Dam. Available online: https://www.usbr.gov/projects/index.php?id=74 (accessed on 8 June 2022).
58. California Department of Parks and Recreation. Folsom Dam. Available online: https://www.parks.ca.gov/?page_id=882 (accessed on 8 June 2022).
59. California Department of Parks and Recreation. Folsom Lake SRA. Available online: https://www.parks.ca.gov/?page_id=27979 (accessed on 8 June 2022).
60. California State Parks, Folsom Lake State Recreation Area & Folsom Powerhouse State Historic Park Road & Trail Management Plan: PUBLIC REVIEW DRAFT 19 May 2022. 2022. Available online: https://www.parks.ca.gov/pages/1324/files/Folsom%20RTMP_PublicDraft_Sept_21_2022_Optimized.pdf (accessed on 8 June 2022).
61. State Park & Recreation Commission. General Plan & Resource Management Plan Vol 1: State Park and Recreation Commission. Available online: https://www.parks.ca.gov/pages/21299/files/FLSRA_GP_RMP_Vol1_Final_Plan.pdf (accessed on 8 June 2022).

62. State Park & Recreation Commission. General Plan & Resource Management Plan Vol 2: State Park and Recreation Commission. Available online: https://www.parks.ca.gov/pages/21299/files/FLSRA_GP_RMP_Vol2_EIR_EIS.pdf (accessed on 8 June 2022).
63. Fletcher, J.E. A Report of Findings for the On-Site Survey of Recreation Users and Telephone Survey of Area Residents for Folsom Lake State Recreation Area. Available online: https://www.parks.ca.gov/pages/21299/files/visitor%20and%20telephone%20survey%20report%20for%20folsom%20lake%20sra.pdf (accessed on 8 June 2022).
64. California Department of Parks and Recreation. Folsom Dam F.A.Q.s. Available online: https://www.parks.ca.gov/?page_id=883#:~{}:text=During%20a%20normal%20run%2Doff,are%20released%20for%20flood%20control (accessed on 8 June 2022).
65. Central Valley Flood Protection Board. Folsom Dam Water Control Manual Update: Final Supplemental EA/EIR. 2019. Available online: http://cvfpb.ca.gov/wp-content/uploads/2019/01/FINAL-Folsom-WCM-Update-SEAEIR.pdf (accessed on 8 June 2022).
66. U.S. Department of the Interior, Bureau of Reclamation. Mid-Pacific Region, Folsom Dam Division, Central Valley Project. Available online: https://www.usbr.gov/mp/mpr-news/docs/factsheets/folsom-dam-reservoir-powerplant.pdf (accessed on 8 June 2022).
67. U.S. Energy Information Administration. Wholesale Electricity and Natural Gas Market Data. Available online: https://www.eia.gov/electricity/wholesale/#history (accessed on 8 June 2022).
68. Global Energy Observatory. Folsom Hydro Power Plant, CA, USA. Available online: http://globalenergyobservatory.org/geoid/598 (accessed on 8 June 2022).
69. Baker, R.; Ruting, B. *Environmental Policy Analysis: A Guide to Non-Market Valuation*; Productivity Commission Staff Working Paper; AgEcon: Canberra, Australia, 2014.
70. Khan, I.; Zhao, M.; Khan, S.U.; Yao, L.; Ullah, A.; Xu, T. Spatial heterogeneity of preferences for improvements in river basin ecosystem services and its validity for benefit transfer. *Ecol. Indic.* **2018**, *93*, 627–637. [CrossRef]
71. Low Impact Hydropower Institute. Complete Application Received—Folsom Dam Project, California. Available online: https://lowimpacthydro.org/complete-application-received-folsom-dam-project-california/ (accessed on 10 June 2022).
72. U.S. Department of Agriculture. Expense—Measured in $/Acre. Available online: https://app.usda-reports.penguinlabs.net/?year=2021&crop=rent_cash_cropland&statistic=expense_dollars_acre (accessed on 10 June 2022).
73. Structurae. Reinforcement of the Folsom Dam in California. Available online: https://structurae.net/en/products-services/reinforcement-of-the-folsom-dam-in-california (accessed on 10 June 2022).
74. EDF. The True Cost of Carbon Pollution. Available online: https://www.edf.org/true-cost-carbon-pollution#:~{}:text=The%20social%20cost%20of%20carbon%20is%20a%20measure%20of%20the,per%20ton%20in%20today\T1\textquoterights%20dollars (accessed on 10 June 2022).
75. International Hydropower Association. Hydropower's Carbon Footprint. Available online: https://www.hydropower.org/factsheets/greenhouse-gas-emissions (accessed on 10 June 2022).
76. U.S. Department of the Interior Bureau of Reclamation Mid-Pacific Region. Auburn-Folsom South Unit Central Valley Project Technical Memorandum: Economic Benefits Update. Available online: https://www.usbr.gov/mp/ccao/docs/auburn_rpt/append-c-tech-memo-eco-benefits-update.pdf (accessed on 13 June 2022).
77. San Juan Water District Schedule of Rates, Fees, Charges and Deposits Calendar Year 2022. Available online: https://www.sjwd.org/files/8dfa6cadf/2022+Fees%2C+Charges%2C+Deposits+3.24.22.pdf (accessed on 13 June 2022).
78. Cooley, H.; Phurisamban, R.; Gleick, P. The cost of alternative urban water supply and efficiency options in California. *Environ. Res. Commun.* **2019**, *1*, 042001. [CrossRef]
79. San Juan Water District. Retail & Wholesale 2020: Urban Water Management Plan. Available online: https://www.sjwd.org/files/5f7a2a821/SJWD+2020+UWMP+Final+06.23.21.pdf (accessed on 13 June 2022).
80. California Agricultural Water Prices by Water District. Available online: https://aquaoso.com/blog/california-agricultural-water-prices/ (accessed on 13 June 2022).
81. California Department of Parks and Recreation. Park Fees. Available online: https://www.parks.ca.gov/?page_id=27186 (accessed on 10 June 2022).
82. Division of Boating and Waterways (State of California). Sacramento—San Joaquin Delta Boating Needs Assessment 2000–2020. Available online: https://dbw.parks.ca.gov/?page_id=29440 (accessed on 18 June 2022).
83. Center for Watershed Sciences Watershed Sciences Building (University of California, Davis). Folsom Dam. Available online: https://watershed.ucdavis.edu/shed/lund/dams/Folsom/FolsomDam.html (accessed on 14 June 2022).
84. IEA. *Hydropower Special Market Report Analysis and Forecast to 2030*; IEA: Paris, France, 2021.
85. Texas Comptroller of Public Accounts. Texas' Electricity Resources Where Power Comes from—And How It Gets to You. Available online: https://comptroller.texas.gov/economy/fiscal-notes/2020/august/ercot.php (accessed on 14 June 2022).
86. University of California at Berkeley. Externalities 131 Undergraduate Public Economics Emmanuel Saez UC Berkeley. Available online: https://eml.berkeley.edu/~{}saez/course131/externalities1_ch05_new.pdf (accessed on 18 June 2022).
87. FEMA. Comparative Emergency Management Session 17: Assessing and Selecting Mitigation Options. Available online: https://training.fema.gov/hiedu/docs/cem/comparative%20em%20-%20session%2017%20-%20assess%20and%20select%20mitigation%20options.doc (accessed on 15 June 2022).