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The Extraction of Prerequisite Criteria for Environmentally Certified Adaptive Reuse of Heritage Buildings

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Abstract: Heritage buildings provide a remarkable value for both the culture and the region where they are located; hence, there is a necessity for them to be conserved. Sustaining heritage buildings for future generations serves cultural sustainability and can be achieved through adaptive reuse with appropriate functions as an efficient conservation approach. Moreover, harnessing the embedded energy from adaptive reuse and the improvement of environmental performance in heritage buildings plays a significant role in ecological sustainability. The aim of the study was to investigate environmental rating systems (ERS) as ecological sustainability evaluation tools and to find out mutual aspects with adaptive reuse models (ARM), thus, serving cultural sustainability.

Keywords: architectural conservation; cultural sustainability; ecological sustainability; environmental rating systems; adaptive reuse models

Citation: Farjami, E.; Türker, Ö.O. The Extraction of Prerequisite Criteria for Environmentally Certified Adaptive Reuse of Heritage Buildings. *Sustainability* **2021**, *13*, 3536. https://doi.org/10.3390/su13063536

Academic Editor: Mariateresa Lettieri

Received: 11 February 2021
Accepted: 18 March 2021
Published: 22 March 2021

1. Introduction

Cultural heritage depicts lifestyles that have shaped societies as time passed and were transferred from ancestors to descendants by practical customs [1]. Restoring and conserving heritage, such as architectural sites, needs close attention because of the congenital nature of cultural heritage as a system [2]. Shetabi [3] expressed that, in the development strategies of UNESCO [4], culture is considered as significant as the concepts of justice, human rights, and sustainability. As a symbol of cultural identity, cultural heritage needs to be sustained for future generations. Heritage has greatly contributed to environmental sustainability, as can be seen in conventional knowledge and pragmatism, since heritage "promotes an ecologically sustainable pattern of production and consumption and sustainable urban and architectural design solutions" [3].

Recent debates have been concerned with the potential of heritage conservation to contribute to environmental sustainability by reducing the energy associated with building structures. In 2015, the World Heritage Committee started to use a policy that integrated a sustainable development viewpoint into the procedures concerning world heritage [5]. It aligned with the United Nation's (UN) 2030 Agenda for Sustainable Development and defined the means by which world heritage can help the three key aspects of sustainable development: environmental sustainability, inclusive social development, and inclusive economic development [5,6]. Adaptive reuse refers to upgrading buildings for new functions. For instance, by taking control of the embedded energy via adaptive reuse and upgrading old buildings in terms of environmental friendliness, passive heating and cooling, harnessing of natural light, improving water infrastructure and achieving energy efficiency are occurring [6–9]. The major difficulty of adaptive reuse is the integration of such sustainable designs with the preservation of buildings and their historic value [10]. Environmental importance and sustainability are strongly related, specifically when it comes to the environmental value, such as restoring and conserving land and reducing pollution and construction waste. They are also related in terms of the relationship between heritage and environment or space (embedment of heritage in space; interaction of natural and cultural heritage; and restoration of heritage as a part of spatial planning) [11]. In addition, all modifications to the heritage building (HB) need to be made by considering maintenance in preservation of the original structure and materials. By improving the sustainability and efficiency of the historical building in terms of the environment and energy, cultural heritage is expected to sustain its unique nature and arrangement [12].

1.1. Aim and Objectives

Regarding the previous research on adaptive reuse, the complex part of the study is the absence of information about applying both environmental rating systems (ERS) and adaptive reuse models (ARM) on heritage buildings in particular. The problem appears when extracting the mutual features within both ARM and ERS that are intertwined with heritage buildings. As for cultural sustainability, ARM address the innovative evaluation method for heritage buildings. Furthermore, using ERS as ecological sustainability tools under the environmental sustainability umbrella is the innovative part of the combination. Based on the Venice Charter [13] and the Burra Charter [14], guidance for assessing and managing change and additions in heritage building is required. The aim of this study was the alignment of related features in both ERS and ARM to create a unique alignment schema for certified adaptation of heritage buildings for improving cultural and ecological sustainability of HB. The proposed alignment schema was derived from all aspects of ARM and ERS related to heritage buildings.

1.2. Material and Methods

Heritage buildings can find new, mixed, or extended uses by logical conversion processes, increasing their values and enhancing their cultural significance [15]. Adaptive reuse of cultural heritage, as a significance of conservation, expresses the rehabilitation, redevelopment, and retrofit of HB that reveals the changing community needs [16]. By considering local needs and enhancing and conserving built heritage value, a broad range towards sustainable development has been enlightened [17]. This study contains qualitative research methods. Data collection methods focused on literature survey via investigation of mutual features of ARM and ERS in order to achieve the particular alignment schema. Accordingly, the extraction of related features was based on grounded theory as a qualitative research method. Qualitative data collection was performed for two different topics within this study. The grounded theory research method was used for the selection of both ARM and ERS, which have special focus on heritage buildings. Historical buildings are treasured originals since they have congenital heritage value. Thus, these buildings need to be specifically cared for, treated, and protected. Such building stocks, when incorporating environmental systems in their conversion designs, can alleviate the problems caused by global environmental issues like high-energy consumption and greenhouse gasses [18,19]. Through redesign and renovations, architects are able to dramatically decrease energy consumption, improve indoor temperature conditioning, and at the same time, maintain the heritage value of such buildings [16,20]. The Burra Charter states that maintaining these buildings has to be a priority and it must "be distinguished from repair because repair involves restoration or reconstruction" [21]. Furthermore, cultural heritage and architectural features in existing buildings help sustainable development and therefore require consideration [22].

2. Significance of Green Approaches for Heritage Buildings (HB)

Progressively, the efficiency of conservation measures available for heritage buildings can be evaluated for how building conservation costs and conservation theory meld with environmental sustainability. Significantly, conservation also extends their life and capacity, including repair, maintenance, and restoration. Heritage buildings' conservation and sustainability are two interrelated concepts and are frequently encountered when it comes to maintenance and repair [23,24].

Heritage buildings have the potential to evolve environmental sustainability while strengthening the resilience of communities [25]. Research preventing energy waste without spoiling the values and historical significance of heritage buildings can make conservation difficult [26,27]. As a major aspect of the world's revitalization strategy to advance sustainability in its environment, numerous structures of verifiable social importance are being adjusted and reused as opposed to being demolished [28–32].

Adaptive reuse is recognized as a conservation strategy [14,21,33], Adaptive reuse of built heritage on the point of conservation strategy is defined as a critical change to a current structural work when the previous function becomes obsolete; while there is an option in contrast to customary destruction and rebuilding; therefore, it is intrinsically feasible as it consumes less energy and produces less waste [31,34,35].

Adaptive reuse has been adopted for various types of historical buildings, such as those for defence, airfields, government, industry, and education [36]. Adaptive reuse is acknowledged in various settings and requires the discovery of new financing and administration models [37].

The way to a fruitful adaptive reuse is to comprehend the heritage building with the current (or lost) energy efficiency aspects. Thus, available energy-efficient and environmentally sustainable features of the building need to be evaluated alongside qualities like historical, architectural, aesthetic, and social [3]. For Zushi [38], successful adaptive reuse projects need building designs and careful plans that take into account the surrounding environment. The holistic approach of this study targets achieving a unique alignment schema for adaptive reuse of heritage buildings through getting inspiration from various categories of ARM, to serve cultural sustainability, and ERS, to serve ecological sustainability (Figure 1).

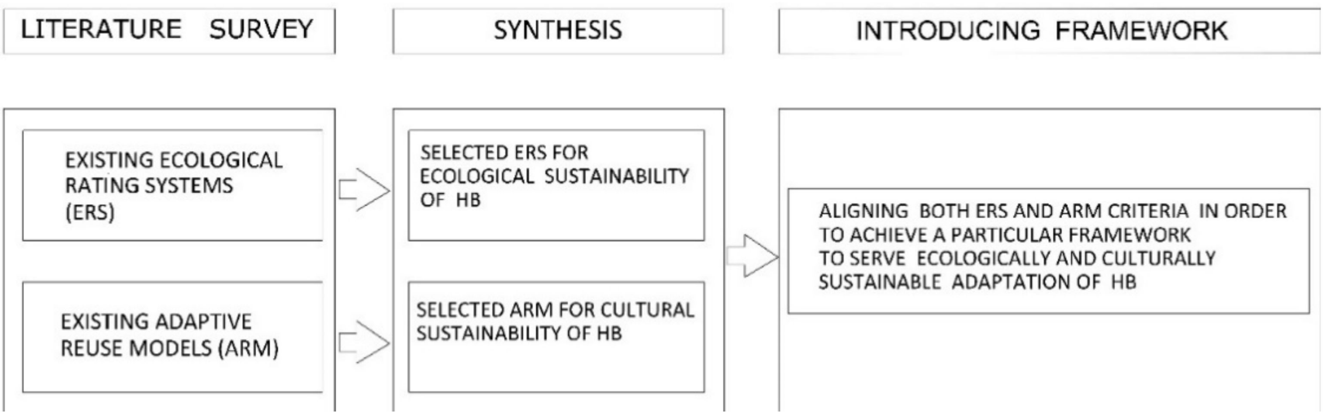

Figure 1. The structure of the study, which describes various stages of the methodology.

2.1. ARM to Serve Cultural Sustainability

On an international scale, important administrative and legislative actions with regard to conservation were introduced by the "Athens Charter" in 1931. In this document, a very delicate urban design is recommended for nearby historical monuments by taking special consideration of the aesthetic value of the heritage together with its context [39,40].

For the last 40 years or so, there have been special attempts in the conservation of architectural heritage, ranging from single monument preservations with aesthetic and historic value to taking measures to help sustainable development of the region in economic, social, environmental, and cultural ways [30,41,42]. This is because the first official definition of cultural heritage, defined and described in the Convention Concerning the Protection of the World Cultural and Natural Heritage of the United Nations Educational, Scientific, and Cultural Organization (UNESCO), was only introduced in 1972 [43]. Various scholars defined several value types attached to cultural heritage. Such types of value were presented with associated terminology, such as historical, socio-economic, symbolic, age-related, architectural, educational, contextual, aesthetic, and emotional [16,17,21,33,44–47]

The Burra Charter stated that adaptation is acceptable only where the adaptation has minimal impact on the cultural significance of the place, and minimal changes to the significant fabric should take place after considering alternatives [34]. Experts in adaptive reuse have been assessing reuse capability of heritage buildings according to related models since 1979 in the Burra Charter, Australia. Adaptive reuse of buildings has the capability to replace demolition since it produces less waste and requires less energy. Its advantages to society include rejuvenation of natural tourism spots and giving tourists a fresh life [48]. In addition, adaptive reuse is a model procedure for conservation of authentic structures regarding their legacy.

Douglas [34] stated that, as the danger of becoming outdated and deteriorated increases, the degree of mediation increases as well. Adaptation projects have a range from essential protection to rebuilding (Table 1). In the middle of these two extremes, in almost top to bottom order are interventions such as conservation, refurbishment, rehabilitation, renovation, remodelling, and restoration.

Table 1. The range of interventions (adapted from Douglas [34] (p. 3).

Level of Intervention (Minimum to Maximum)	Type of Intervention	Explanation
Preservation: arrest decay	Maintenance	Basic adaptation works including fabric repairs.
Conservation: preserve purposefully	Maintenance Stabilization	Basic adaptation works including fabric repairs. Strengthening and major improvement works to the structure.
Refurbishment: facelift or makeover	Stabilization	Strengthening and major improvement works to the structure.
Rehabilitation: modernization	Stabilization	Strengthening and major improvement works to the structure.
Renovation: upgrading	Stabilization Consolidation	Strengthening and major improvement works to the structure. Medium adaptation and maintenance works.
Remodeling: improving/extending	Consolidation	Medium adaptation and maintenance works.
Restoration: bringing back	Consolidation Reconstruction	Medium adaptation and maintenance works. Substantial rebuilding of part or parts of the building.
Demolition: removing	Reconstruction	Substantial rebuilding of part or parts of the building.

ARM's role is to recognize and rank the capability of adaptive reuse in existing structures and, in this manner, can be portrayed as a mediation technique to guarantee that aggregate social worth is improved and future redundancy is planned. In addition, it needs an evaluation of physical, economic, functional, technological, social, legal, political, and environmental out-datedness. The evaluation utilizes substitute estimation methods since no immediate market proof exists [49]. ARM from around the world related to the importance of adaptive reuse for heritage buildings have been compiled in Table 2.

In Table 2, there are three categories of ARM, where the first column shows the models to be used in adaptive reuse process of HB through standards and provided scoresheets; and the second and third columns mark software used in certain processes like designing a historical building reuse project and documentation systems related with cultural heritage consecutively.

Table 2. Classification of ARM from around the world in accordance with their relation to adaptive reuse of heritage buildings.

No:	Country and Year	Name	Management	Scope	AR Models for HB	AR Software for HB	Documentation System for HB
1	America (1930s)	HABS	Historic American Building Surveys	"By abiding to such an intense documentation routine that promotes hands-on engagement with a historic structure, a deeper understanding of the historic fabric is achieved and thus is reflected in an accurate set of documentation for the Heritage Documentation Program's archive (HDP)" [49]			x
2	America (1970)	BIM	Building Information Modelling	"New paradigm of digital design and management, shows great potential for the refurbishment process" [50].		X	
3	Australia (2004)	PAAM	Preliminary Assessment of Adaptation Potential	"PAAM is a reliable diagrammatic representation of the relationship between key significant decision-making criteria and building adaptation" [51]. "The PAAM model facilitates a relatively fast and deeper understanding of the adaptation potential of a building and highlights the important property attributes which are likely to present issues for stakeholders" [52,53].	x		
4	Australia (2007)	ARP	Adaptive Reuse Potential	"The ARP model provides a reasonable straightforward method for accessing effective useful life and adaptive reuse potential (ARP) in existing buildings." "The concept of adaptive reuse potential (ARP) provides a robust assessment of the effective useful life of a historic building, taking consideration of factors affecting obsolescence. The ARP model predicts useful life as a function of (discounted) physical life and obsolescence and allows the calculation of the adaptive reuse potential" [31].	x		
5	Ireland (2009)	HBIM	Historic Building Information Modelling	"Historic Building Information Modelling (HBIM) is a novel prototype library of parametric objects, based on historic architectural data and a system of cross platform programmes for mapping parametric objects onto point cloud and image survey data" [54].		x	

Table 2. *Cont.*

No:	Country and Year	Name	Management	Scope	AR Models for HB	AR Software for HB	Documentation System for HB
6	Australia (2010)	AdaptSTAR	Adapt Star Model	"A new design rating tool called adaptSTAR, is a weighted checklist of design strategies that lead to future successful adaptive reuse of buildings." "AdaptSTAR model can empower designers of buildings to make critical decisions that contribute to improving longevity and future reuse" [22].	x		
7	Malta (2011)	CHIMS	Cultural Heritage Information Management System	"The main objective of CHIMS is to create a new knowledge-based context for understanding, managing and disseminating data concerning cultural heritage. CHIMS aims at enabling access to cultural heritage as a requirement for protection as well as a fundamental human right" [55].			x
8	Lithuania (2018)	CHPP	Cultural Heritage Perception Potential	"The CHPP model requires analyzing the indicators which establish the impression for people to evaluate buildings as cultural heritage by contextual analysis" [4].			x

As Table 2 presented, this study emphasizes ARM in the first category by collecting detailed information of each model with a focus on evaluation system, and it is shown in Figure 2, whose results will be used in evaluation criteria based on ecological sustainability features in the alignment part.

Figure 2 displays the variety of ARM from around the world related to heritage buildings that were introduced in previous Table 2. In Figure 2, analyses of the related models in terms of their scope, in addition to direct or indirect relations to HB, the evaluation tools and software, and their problems and limitations are outlined. The information in Figure 2 has been collected from various sources in order to clarify each ARM methodology to be used by users who are leading adaptive reuse projects. Based on the type of HB obsolescence, they can implement the design criteria and sub-criteria to overcome obsolescence within the related category or to avoid further obsolescence.

Figure 2 investigates ARM with direct relation to HB in order to extract their HB-related features as the first component of the alignment schema to be proposed.

By addressing the analysed documents from selected ARM with direct relation to heritage buildings (Figure 2), the pointed criteria will be assisted in the evaluation part of the study in order to achieve the mutual features to shape the proposed alignment schema.

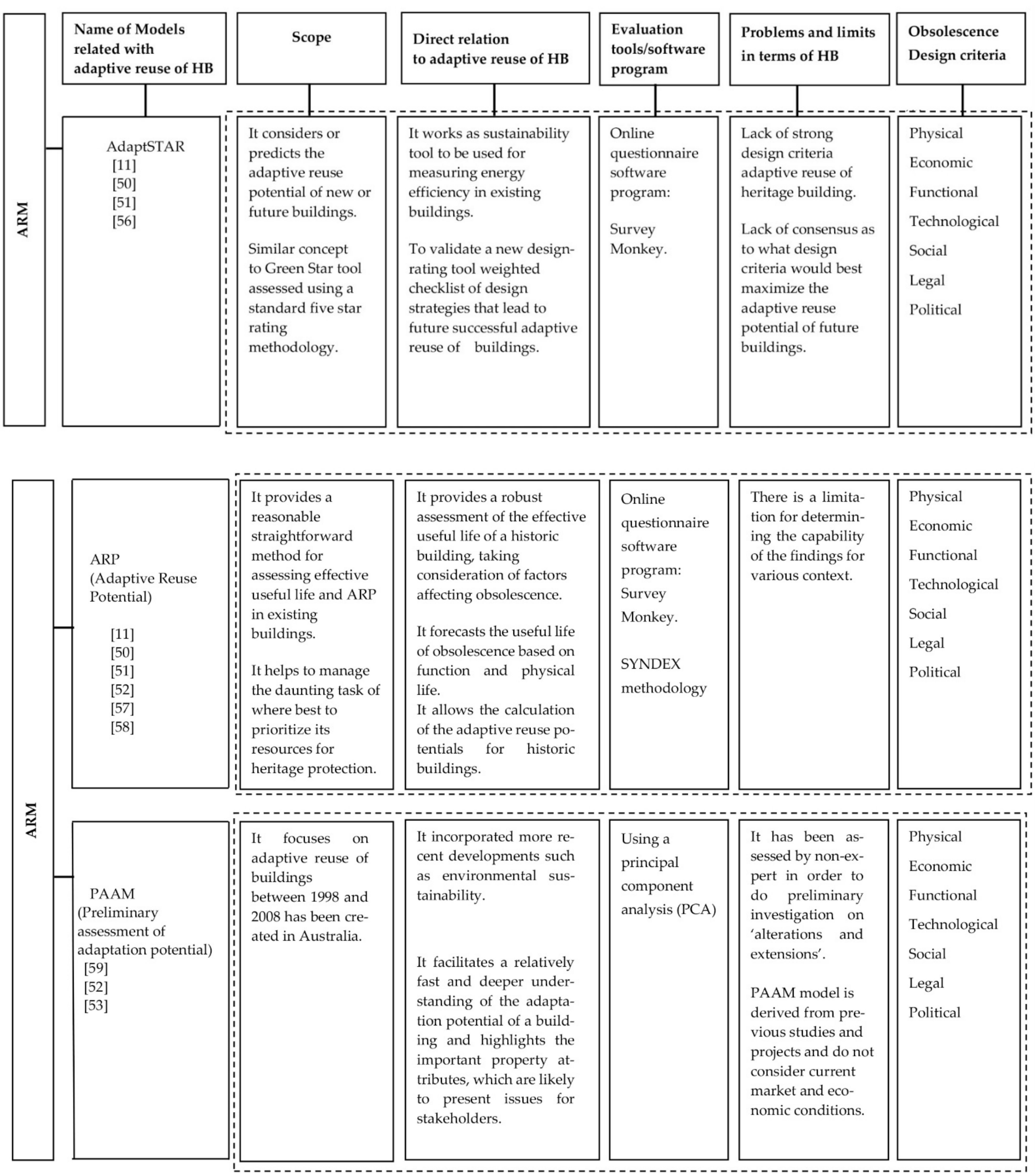

Figure 2. Analysis of ARM worldwide, with their direct and indirect relations to adaptive reuse of heritage buildings Ref [11,52–59].

2.2. Environmental Rating Systems to Serve Ecological Sustainability in HB

Recently, integrating heritage conservation with environmental issues has been an intrinsic characteristic of backing up sustainability [60,61]. The United Nations Environment Program (UNEP) [62] underscored that the building sector must concentrate more on adjusting and retrofitting of existing structures to the ideal energy efficiency standard. In addition, UNEP considered the capacity of historic buildings for energy-saving contributions as "the least important aspect of the relationship of heritage to sustainability", emphasizing rather "the cultural and social contribution that heritage makes every day to how lives are lived, and to the ways in which identities and relationships are formed" [63] (p. 22). Identifying historical worth must be an integral stage of a sustainable building process, focusing on the preservation and upgrade of all its past configurations with the aim of identifying, enriching, and transmitting cultural heritage to descendants. ERS are suggested for upgrading a building's sustainability level without putting its heritage value at risk [64,65].

Environmental appraisal instruments or rating frameworks cannot overlook legacy structures. Besides, for example, benchmarks and rules, confirmation frameworks, contracts, and models are significant instruments for quality affirmation in cultural heritage management [19,66]. Key environmental sustainability measures that can be considered in the adjustment of heritage buildings are equivalent to those applicable to non-legacy stock. In particular, measures may include energy efficiency, water proficiency, decrease of waste, presentation of recycling and waste management, detail of low environmental impact materials, and effective building activity and facility management. Such actions can lessen environmental impacts of buildings and are perceived that way because of their consideration in ecological appraisal instruments. The instruments are utilized to assess the degrees of sustainability accomplished in green structures [62,63].

ERS can be used for projects seeking a range of intervention degrees from preservation to renovation. In all cases, the main goal of the process must be the historic building's major renovation and the interior space renewal or functional reorganization, considering a building envelope's performance improvement consistent with the preservation of the heritage, architectural, and construction features [12,63]. In this study, ERS from around the world have been collected and classified according to their relation type to HB as is shown in Table 3.

Table 3. Classification of ERS from around the world, according to their relationship with adaptive reuse of heritage buildings.

NO	Country	Name	Management	Related with AR of HB	Indirectly Related with AR of HB	Non-Related with AR of HB
			Africa			
1	South Africa	Green Star SA	South Africa GBC			X
2		SBAT	CSIR (Council for Scientific and Industrial Research			X
3	Northeast Africa	GPRS	(Green pyramid rating system)	X		
			Asia			
4	China	GHEM	China Real Estate Chamber of Commerce		X	
5		GOBAS	Minister of Science and Technology		X	
6		DGNB	DGNB China		X	
7		ESGB	Ministry of Housing and Urban-Rural Construction			X
8	Hong Kong	BEAM Plus	HK-BEAM Society			X
9		CEPAS	Comprehensive Environmental Performance Assessment Scheme for Buildings	X		
10		HK-BEAM	Hong Kong Building Environment Assessment Method			X
11		IBI	The Intelligent Building Index			X
12		BQI	The Building Quality Index			

Table 3. *Cont.*

NO	Country	Name	Management	Related with AR of HB	Indirectly Related with AR of HB	Non-Related with AR of HB
13	India	TERI-GRIHA	The Energy and Research Institute (TERI)		X	
14		LEED® India	Indian GBC		X	
15	Japan	CASBEE	Japan Sustainable Building Consort	X		
16		NIRE-LCA	National Institute for Resource and Environment			X
17	Korea	GBCC	Korean Korea Institute of Energy Research		X	
18	Singapore	Green Mark	Singapore Building and Construction Authority			X
19	Taiwan	EEWH	Architecture and Building Research Institute			X
20	Thailand	DGNB	ARGE—Archimedes Facility-Management GmbH, Bad Oeynhausen and RE/ECC			X
21	Vietnam	LOTUS	Vietnam GBC			X
22	Egypt	GBRSs	(Green Building Rating Systems)		X	
			Europe			
23	Austria	BREEAM AT	DIFNI		X	
24		DGNB	ÖGNI		X	
25	Belgium	LEnSE	Belgian Building Research Institute			X
26	Bulgaria	DGNB	Bulgarian GBC		X	
27	Czech Republic	DGNB	DIFNI		X	
28		SBToolCZ	iiSBE International, CIDEAS		X	
29	Denmark	BEAT 2002	SBI		X	
30		DGNB	Denmark GBC		X	
31	Finland	PromisE	VTT			X
32	France	HQE™ Method	HQE™		X	
33		ESCALE	CSTB and the University of Savoie			X
34	Germany	DGNB	German Sustainable Building Council		X	
35		BREEAM DE	DIFNI		X	
36	Greece	DGNB	DIFNI		X	
37	Hungary	DGNB	DIFNI		X	
38	Italy	GBC HB/LEED®Italia	Italy Green Building Council—Historic Buildings	X		
39		Protocollo ITACA	iiSBE Italia	X		
40	Luxembourg	BREEAM-LU	DIFNI		X	
41	Netherlands	BREEAM-NL	Dutch GBC		X	

Table 3. *Cont.*

NO	Country	Name	Management	Related with AR of HB	Indirectly Related with AR of HB	Non-Related with AR of HB
42	Norway	BREEAM-NOR	Norwegian GBC		X	
43		Økoprofil	SINTEF			X
44	Poland	DGNB	DGNB International		X	
45	Portugal	LiderA	Instituto Superior Técnico, Lisbon	X		
46		SBToolPT	iiSBE Portugal, LFTC-UM, ECOCHOICE	X		
47	Russia	DGNB	DGNB International			X
48	Spain	DGNB	N/A			X
49		BREEAM ES	Fundacion Instituto Technològico de Galicia		X	
50	Sweden	EcoEffect	Royal Institute of Technology			X
51		BREEAM SE	Swedish GBC		X	
52	Switzerland	BREEAM CH	DIFNI		X	
53		DGNB	SGNI		X	
54	Turkey	DGNB	-			X
55	Ukraine	DGNB	DGNB International		X	
56	United Kingdom	BREEAM	BRE	X		
North America						
57	Canada	LEED® Canada	Canada GBC		X	
58		GreenGlobes	ECD Canada		X	
59	Mexico	SICES	Mexico GBC			X
60	United States	LEED®	United States GBC	X		
61		GreenGlobes	Green Building Initiative			X
58		BEES	Building for Environmental and Economic Sustainability			X
Oceania						
59	Australia	Green Star	Australian GBC		X	
60		NABERS	NSW Office of Environment and Heritage	X		
61	New Zealand	Green Star NZ	New Zealand GBC			X
South America						
62	Argentina	LEED® Argentina	Argentina GBC		X	
63	Brazil	LEED® Brazil	Brazil GBC		X	
64		HQE™	Fundação Vanzolini			X

By addressing Table 3 ERS with direct relation to HB have been marked to be under precise information detail. Notably, Figure 3 investigates the selected ERS, which have direct relation to heritage buildings, by evaluating their scope. Furthermore, they were examined in terms of problems/limitations and used software in order to achieve certification for adaptive reuse projects to be ecologically sustainable.

	Name of Models related with adaptive reuse of	Scope	Direct relation to adaptive reuse of HB	Evaluation tools/software program	Problems and limits in terms of HB	Source
ERS	**1. LEED® (The Leadership in Energy and Environmental Design American LEED-ND-V4) 1998**	It discussed about new construction, neighborhood development and mostly historic buildings. The adaptive reuse and historic preservation points has been introduced and it contains the credit for reduction impact of building life-cycle.	It considers preservation and adaptive reuse as value-added in green building projects. LEED-ND projects and historic resources attempt to either create or preserve distinct places, where visitors feel connected to their communities and to the built environment through appreciation of the past or a plan for the future.	Autodesk Ecotect™ Autodesk Green Building Studio (GBS)™ Integrated Environmental Solutions (IES)®, Virtual Environment (VE)™	The problem for preservation is that the authenticity of the structure has not been maintained, a situation which should entail further evaluation.	[63] [67] [68] [69]
ERS	**2. BREAM UK (Building Research Establishment Environmental Assessment Methodology) United Kingdom 1990**	It has been used across Europe, it is an environmental assessment method and rating system for buildings. It has the effect on clients and designers by presenting the importance of energy demands, low design impact and low carbon in building design.	BREEAM Infrastructure 2016 has a category named Landscape and Heritage. A separate scale is provided for heritage buildings to reflect limitations in the scope to reduce energy demand.	IES-VE	The limitation comes out because of considering and heritage buildings. It will be more challenging to achieve developed BREEAM ratings for listed renovations.	[66] [70] [71]
ERS	**3. CASBEE (Comprehensive Assessment System for Built Environment Efficiency) Japan 2001) CASBEE for Renovation - CASBEE-RN**	It is based on the building's life cycle: pre-design, new construction, existing building, and renovation. It presents a new concept of assessment that distinguishes environmental load from quality of building performance.	It developed through evaluating existing building performances according to specifications and predicted performance with renovation. It also measure the improvement of precise performance related to the purpose of the refurbishment. It helps generate proposals for building upgrades and to evaluate improvements. reuse of buildings.	BEE (Building Environmental Efficiency)	CASBEE created just for existing Home program	[66] [72] [73] [74]

Figure 3. *Cont*.

ERS	**4. LIDERA (Lead for the Environment) 2005**	This system can be applied to the different stages of the building process (project, construction, operation/use, maintenance and renovation and demolition)	Enhance local dynamics and promote proper inte-gration (site and integra-tion), with regard to soil, to natural ecosystems, and to landscape and heritage.	LiderA evaluation system	There is a limitation for determining the capability of the findings for various context.	[75] [76]
ERS	**5. SBTool (Sustainable Building Tool) 1996. SBToolPT (the Portuguese chapter of iiSBE)**	It is specifically designed to allow users to reflect on dif-ferent priorities and to adapt it to the environmental, socio-cultural, economic, and technological contexts of different regions.	The greatest constraint to sustainability assessment is that assessment involves subjective rating and depends, above all, on the planned function of the building, as well as on its socio-economic and cultural heritage context. It developa and proposes a generic methodology to assess the sustainability of existing, new and renovated buildings in urban areas. It allows the calculation of the adaptive reuse potentials for historic buildings.	SBTool uses the Science Advisory Board (SAB)	SBToolPT uses the same environmental categories declared in the Environmental Product Declarations (EPDs). Some limitations to this approach due to the scarcity of available EPDs.	[77] [78]
ERS	**6. GBC Historic Building™**	It has been aimed a rating system for certification in level of sustainability for integration, recovery, historic buildings and restoration. It purposes of future transmission, recognition and enhancement are specifically for cultural heritage and significance of historic interests.	GBC Historic BuildingTM is respecting and protecting the cultural value, restoration and heritage buildings with giving special credit as: Historic Value.	Dynamic simulation Engine (EnergyPlus)	The existing tools have weaknesses when the new assessment processes are going to high-light the historical context, preservation and restoration framework.	[62] [63] [64]
ERS	**7. GPRS (Green pyramid rating system Levels) Egypt 2009**	The GPRS sustainable building rating system was developed by the HBRC, which is the national rating and certification system for sustainable new buildings and renovation in Egypt.	Cultural Heritage credit points is obtainable for integrating architectural, construction, and technical solutions that excel in reflecting national and regional cultural heritage while contributing to the environmental performance of the building. GPRS-V2-2017-NB: Sustainable site. Innovation and added value aspect, the "Culture heritage" is well covered in vernacular architecture related modules and "Innovation" is well covered too in the innovation, design studio, and architecture modules.	Statistical com-puter software called : SPSS 250	This system has applicable context limitation.	[66] [79] [80]

Figure 3. *Cont.*

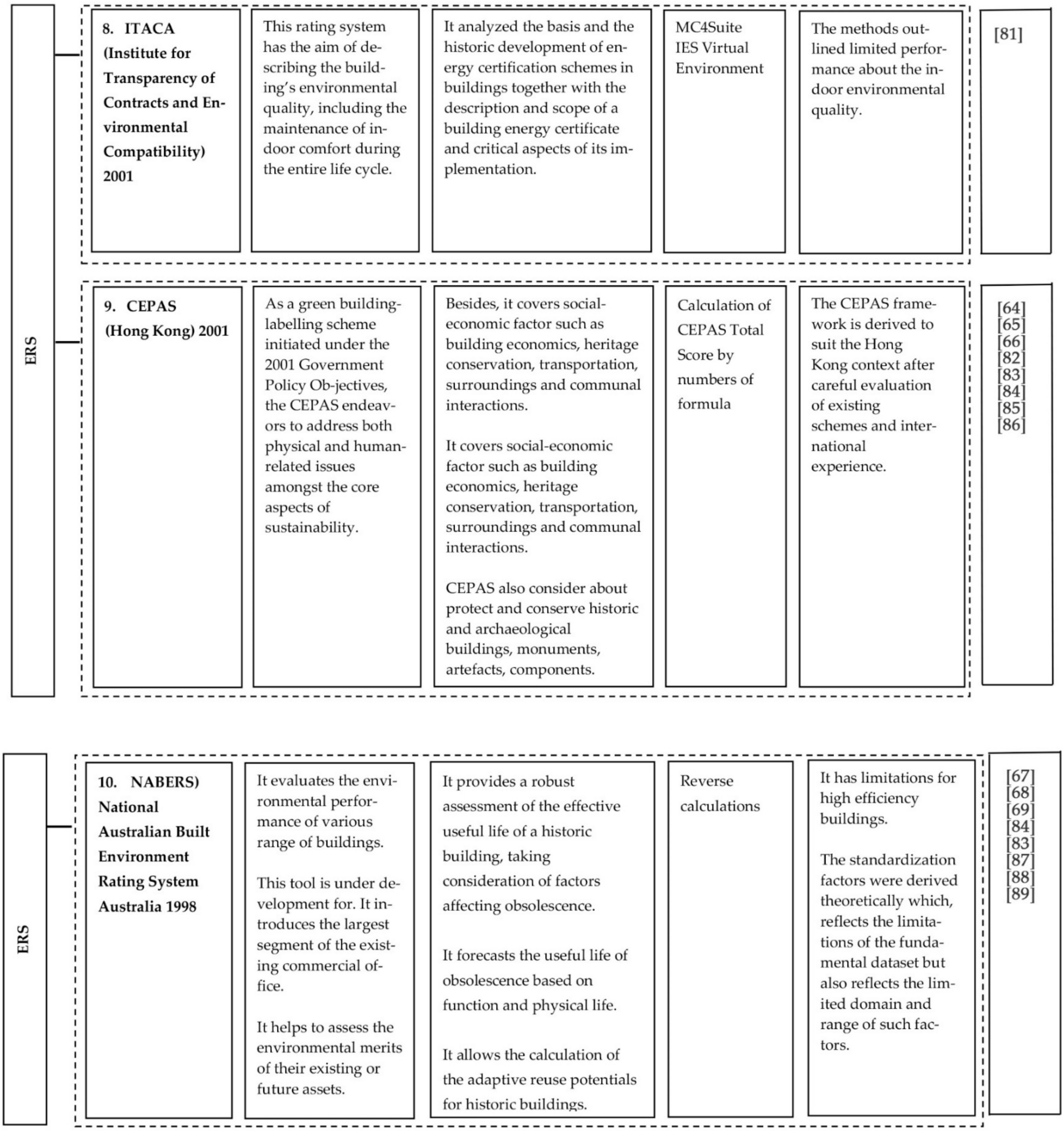

Figure 3. Analysis of ERS worldwide, with their direct and indirect relations to heritage buildings. Refs [62–89].

Figure 3 investigates ERS with direct relation to HB in order to extract their HB-related features as the second component of the alignment schema to be proposed.

Increasing the demand for ecological sustainability in different fields is noticeable, especially in architectural conservation of heritage buildings as was explained in collected data for Tables 1–3. Therefore, this study attempts to align both cultural and ecological design criteria in case of heritage obsolescence, which requires adaptation instead of demolishing in order to accomplish the alignment schema as a result.

3. Integrating Cultural and Ecological Sustainability of Heritage Buildings through a Particular Alignment Schema

Concentration on the improvement of new information with respect to future building adaptive reuse, sustainability issues, and future plan headings will proceed, most likely, at an expanding rate for the following years, pushed by an expanding consciousness of environmental duty [90]. Fournier and Zimnicki [91] planned some rules to give data and direction to the adaptive reuse of buildings, such as reducing development of new structures, which devours critical measures of crude materials and land resources that may be better utilized for different capacities. In line with the aims of heritage preservation and sustainable planning, these rules integrate sustainability into the adaptive reuse of current historical buildings to empower the built environment at the same time as protecting the local culture of the society.

Snyder [92] considered utilizing the common principles in adaptive reuse and sustainable design that lead to development that decreases environmental impact by conserving material and energy. He also stated that adaptive reuse and sustainable design are two important elements in the future of architecture, as is fulfilling the existing requirements of today's buildings and the design of new buildings to make sure that they are sustainable in the future, back up global climate protection, and emissions reduction.

This study is unique with regard to cultural and environmental aspects of sustainable development. It is trying to provide an alignment schema for obtaining certified adaptive reuse of HBs so that it can be used in conservation areas, which was not considered sufficiently in past studies for different types of ARM and ERS. Ecological sustainability and its harmony with other sustainability elements have been taken into account as one of the important aims of sustainability. Alongside this, adjustment of HB yields cultural sustainability via continuation of symbolic, historical, and social values. In the meantime, suitable reuse of HB increases income to maintain the reused HB. Thus, environmentally sustainable reuse of HB provides utmost sustainability in every respect.

In this study, the association between cultural and ecological sustainability is considered to propose the challenges and integrations of ARM and ERS in terms of recommending the alignment schema be applied on heritage buildings. The integration of both cultural and ecological sustainability became significant recently since cultural heritage includes signs of cultural identity. By considering adaptive reuse for conserving heritage buildings as cultural sustainability factors, various adaptive reuse obsolescence design criteria have been specified, such as physical, economic, social, functional, technological, political, environmental, and legal issues. Accordingly, all adaptive reuse obsolete design criteria and sub-criteria have been investigated for achieving the related features to sustainability.

All factors are defined in this section to identify the values of concern. Environmental sustainability has been analysed for years to provide support for the environment considering limitations in energy and use of green design strategies [93]. Heritage buildings also need to be preserved as they provide significant knowledge of the past and present for future generations [15,17]. Ecological sustainability of heritage buildings has become a more concerning issue, and it needs to be a sensitive element of the process. Therefore, it needs to be ensured that building requirements are considered in the problem-solving process and are in line with heritage conservation requirements [93]. The graph presents the procedure of alignment of cultural and ecological sustainability. In parallel, ecological reuse of HB has been investigated in detail in order to find out the HB-related criteria that contributed to sustainability. This procedure has been illustrated in Figure 4, which expresses the collected data from both ARM and ERS with mutual features towards sustainability reuse of HB.

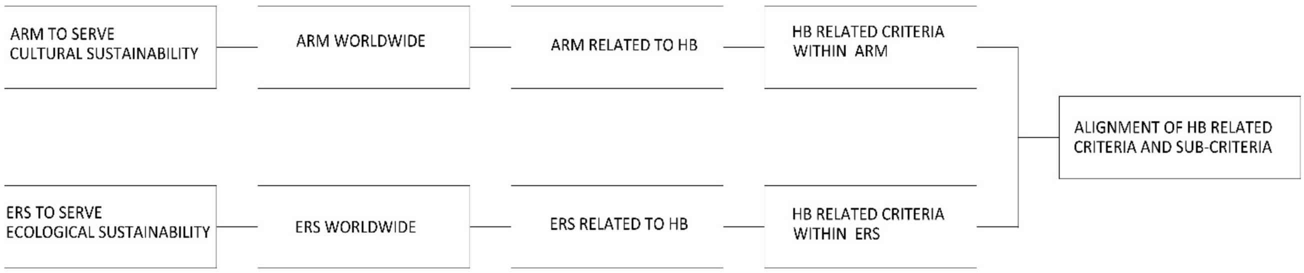

Figure 4. The parallel concepts prior to the alignment of ERS and ARM.

By considering Figure 4, [29] attempted to label precisely the significance of adaptive reuse for cultural sustainability. Consequently, there have to be numbers of obsolete design criteria to support adaptive reuse of heritage buildings, which is explored in further stages.

3.1. Deriving Adaptive Reuse Design Criteria from ARM

Based on the collected data from ARM with related features to heritage buildings, an evaluation examined and revealed the ARM's criteria versus adaptive reuse design criteria. Accordingly, Figure 5 highlights particular ARM criteria related to HBs. The examination was targeted to find certain ARM and their criteria, which have a relationship with cultural heritage. The selected ARM related to HB have been added to Figure 5 in order to prepare the evaluation criteria. In this figure, adaptive reuse design criteria and sub-criteria in relation to HB have been marked and extracted based on the definition made in related original ARM (Table 2). The inclusion of keywords such as heritage building, historic building, architectural heritage, cultural heritage, heritage value, heritage significance, etc., in the original definition, helped the researcher in the determination of related sub-criteria.

Figure 5 presents design criteria and sub-criteria derived from ARM and based on obsolescence categories related to HB. The related features have been collected in the alignment schema for this study in order to clarify the related features of each ARM.

3.2. Deriving Criteria Related to HB from Ecological Environmental Rating Systems

Ecological sustainability principles are focused on the environmental values of design strategy. As for the central fundamental idea of this study, ERS play a core role in the standardization of the ecological principles to be considered in ecologically sustainable adaptive reuse of heritage buildings. Figure 6 represent design criteria and sub-criteria gathered from selected ERS, which are explained in Figure 3 and analysed according to different headings. The marked ones express the features with relations to HB extracted among all features.

In this figure, ecological design criteria and sub-criteria in relation to HB have been marked and extracted based on the definition made in related original ERS (Figure 3). The inclusion of keywords such as historic site, historic interest, cultural interest, heritage building, historic building, architectural heritage, cultural heritage, heritage value, heritage significance, etc., in the original definition helped the researcher in the determination of related sub-criteria.

Figure 6 introduce the HB-related criteria and sub-criteria derived from the inclusive categorization of design criteria extracted from selected ERS worldwide.

In the next section of this study, the marked mutual aspects of ARM and ERS (Figures 3 and 4) are transferred to the proposed particular alignment schema called the prerequisite criteria schema (PCS). PCS includes the criteria and sub-criteria to be initially checked among the inclusive features to be fulfilled in the ecological adaptive reuse process of HB.

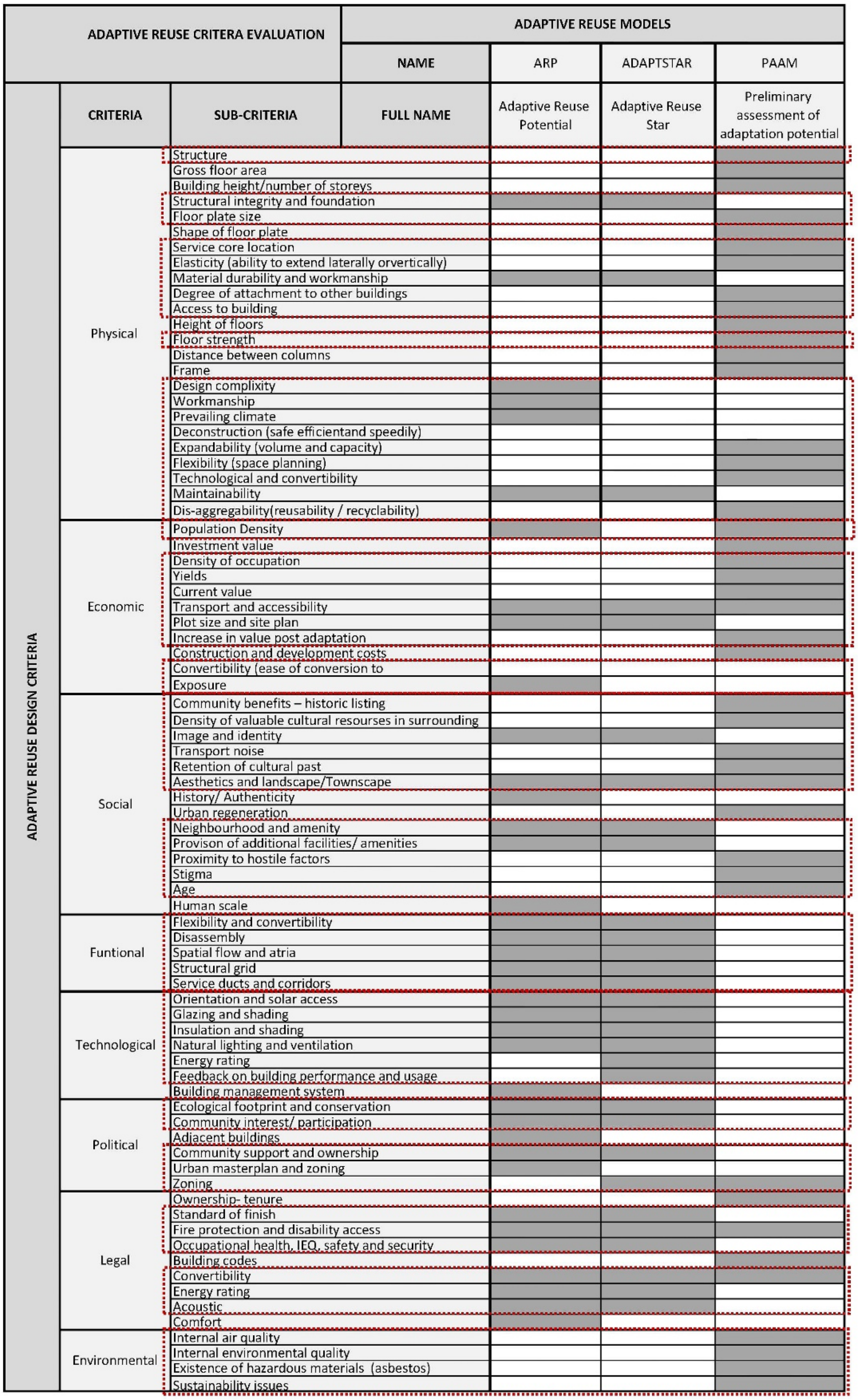

Figure 5. ARM versus adaptive reuse design criteria related with HB.

RATING SYSTEM CRITERA EVALUATION		ERS Criteria	ENVIRONMENTAL RATING SYSTEMS DESIGN CRITERIA																									
		Criteria	Management																Historic Value (HV)									
		Sub-Criteria	Project brief and design	Life cycle cost and service life planning	Responsible construction practices	Commissioning and handover	Aftercare	Containers for site materials waste:	Employing waste recycling workers on site	Access for lorries, plant and equipment	Identified and separated storage areas	Project Waste Management Plan	Engaging a company specialized in recycling and disposal	Protecting water sources from pollution	Waste from mixing equipment	Control of emissions and pollutants	Providing a Building User Guide	Providing a Periodic Maintenance Schedule	Advanced analysis: energy audit	Advanced analysis: diagnostic tests on materials	Advanced analysis: diagnostic tests on structures	Project reversibility	Compatibility of the new use and open communit	Chemical and physical compatibility of mortars	Structural compatibility	Sustainable building site	Scheduled maintenance plan	Specialist in preservation of buildings and sites
HB RELATED ENVIRONMENTAL RATING SYSTEMS WORLDWIDE	NAME	INFO																										
	LEED- V4	2013 (America)																										
	GBC - Historic Building™	2017 (Italy)																	■	■	■	■	■	■	■	■	■	■
	BREEAM	1990 (United Kingdom)	■	■	■	■	■																					
	SBTool	1998 (Canada-SAB)																										
	GPRS	2011 (Egypt)						■	■	■	■	■	■	■	■	■	■	■										
	CASEBEE BD (NC)	2014 (Japan)			■		■	■			■		■	■							■						■	
	NABERS	1998 (Australia)		■					■		■				■													
	CEPAS	2001 (Hong Kong)		■	■	■										■												
	LIDERA	2005 (Portugal)	■	■					■					■		■	■											
	ITACA	2001 (Italy)					■	■				■			■								■					

RATING SYSTEM CRITERA EVALUATION		ERS Criteria	ENVIRONMENTAL RATING SYSTEMS DESIGN CRITERIA																		
		Criteria	Inovation and Added Value			Health and Wellbeing											Pollution				
		Sub-Criteria	Cultural Heritage	Exceeding Benchmarks	Innovation	Visual comfort	Safe containment in laboratories	Security	Safe and healthy surroundings	External lighting	Low carbon design	Energy efficient laboratory systems	Reduction of energy use and carbon emissions standards	Energy monitoring	Energy efficient transport systems	Energy efficient cold storage	Impact of refrigerants	Local air quality	Flood and surface water management	Reduction of night time light pollution	Reduction of noise pollution
HB RELATED ENVIRONMENTAL RATING SYSTEMS WORLDWIDE	NAME	INFO																			
	LEED- V4	2013 (America)																			
	GBC - Historic Building™	2017 (Italy)																			
	BREEAM	1990 (United Kingdom)				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	SBTool	1998 (Canada-SAB)	■																		
	GPRS	2011 (Egypt)	■	■	■	■															
	CASEBEE BD (NC)	2014 (Japan)								■	■									■	
	NABERS	1998 (Australia)																	■		
	CEPAS	2001 (Hong Kong)											■								
	LIDERA	2005 (Portugal)					■			■		■				■	■				
	ITACA	2001 (Italy)				■	■			■									■	■	■

Figure 6. *Cont.*

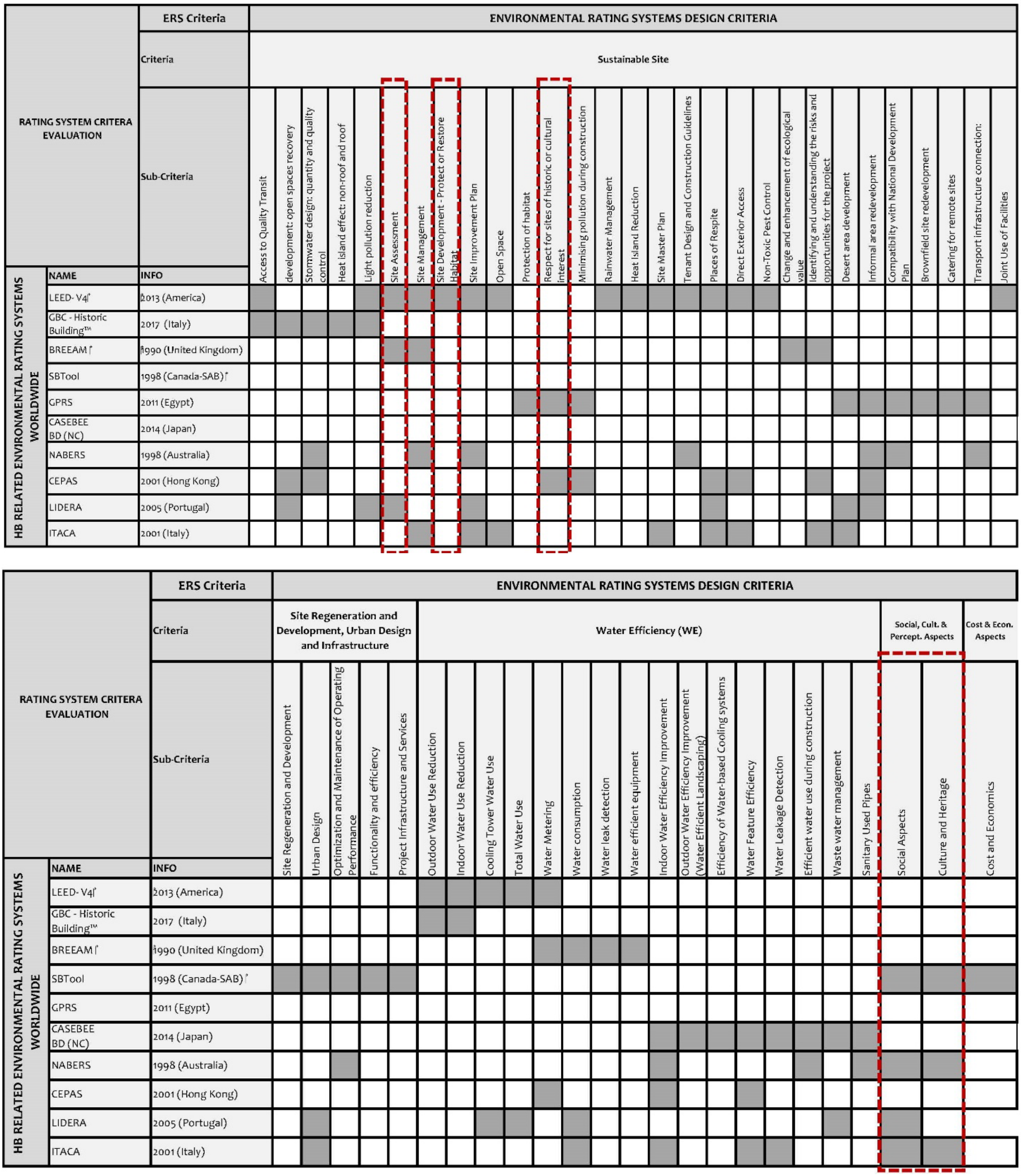

Figure 6. *Cont.*

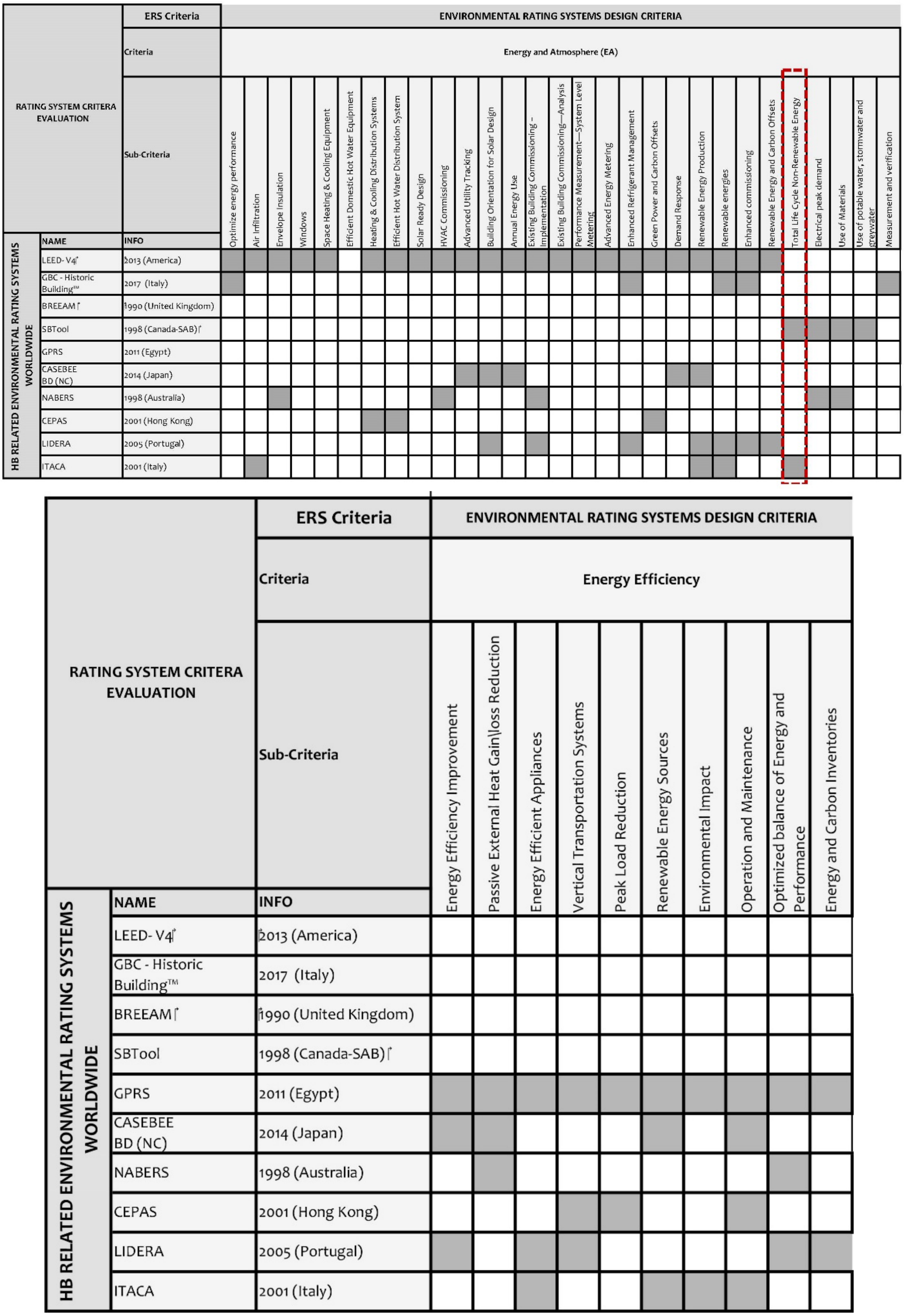

Figure 6. *Cont.*

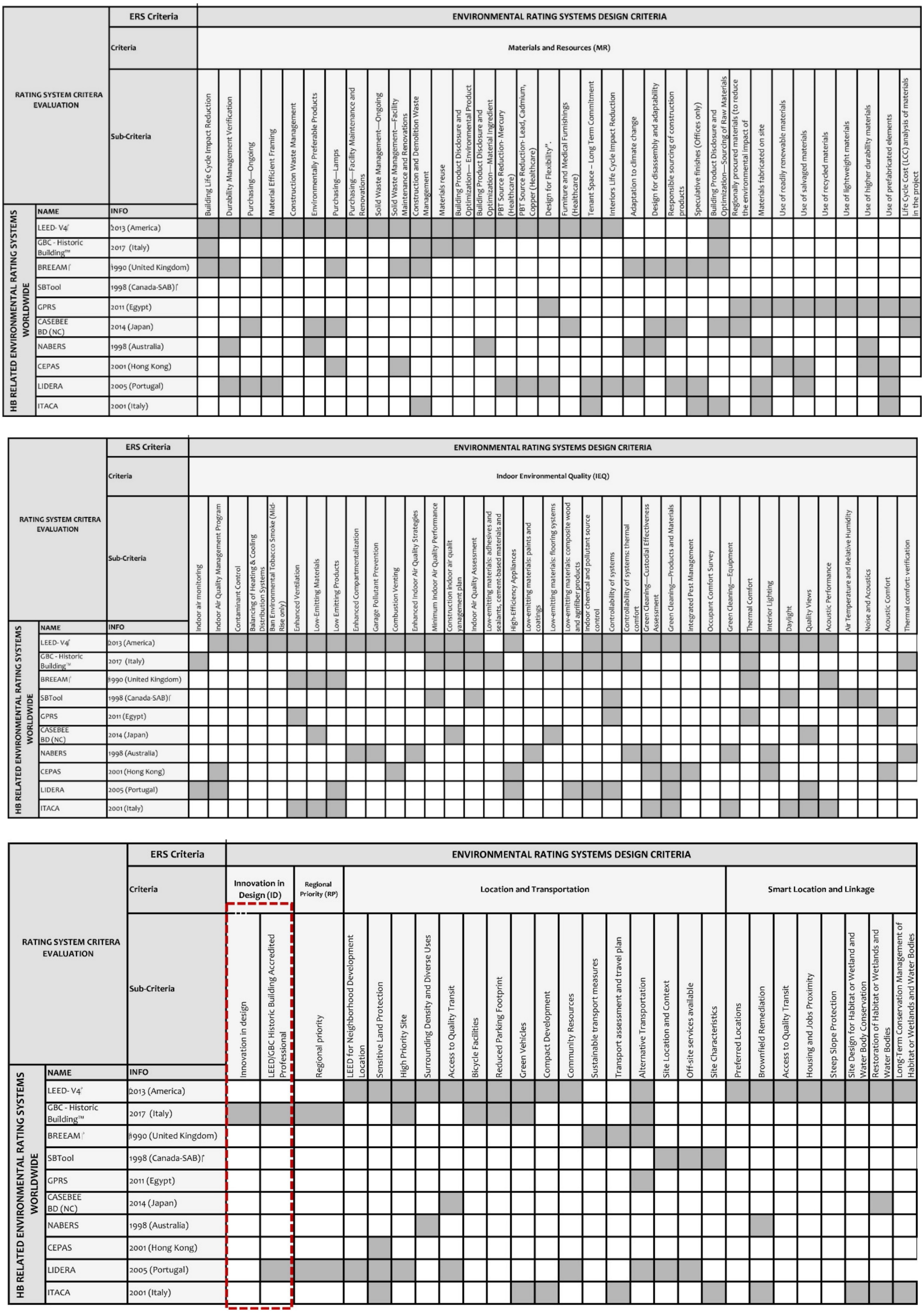

Figure 6. *Cont.*

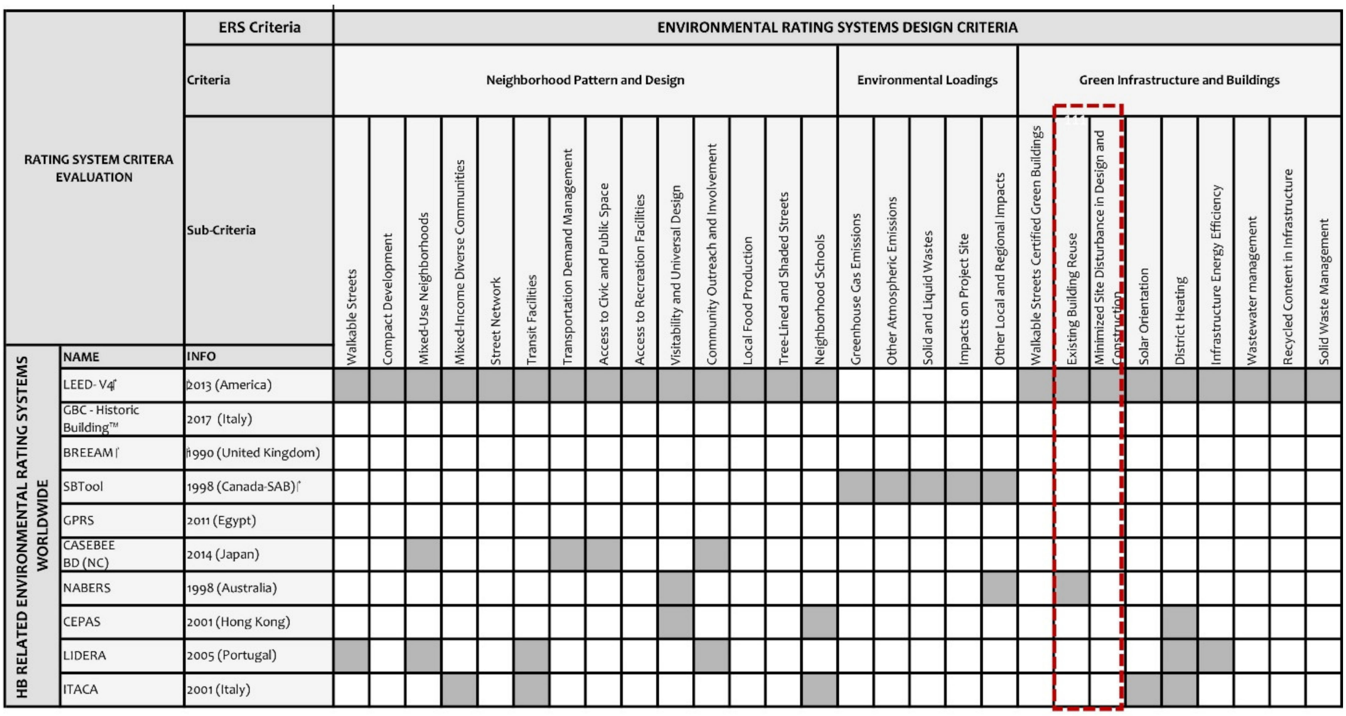

Figure 6. Extracting HB-related criteria from selected ERS.

3.3. The Proposed Prerequisite Criteria Schema (PCS)

Promoting the importance of integrating both ARM and ERS can be framed as a figure that contains the collected data in relation to HBs. The connection to both ARM and ERS criteria and sub-criteria has been explored from their feature descriptions analysis in previous sessions, which attempt to innovate a beneficial PCS for certified adaptive reuse of heritage buildings.

In this manner, PCS was drawn by targeting both "ARM'" as cultural sustainability design criteria and "ERS" as ecological sustainability design criteria in relation to HB. PCS serves as the initial step within the procedure of achieving green adaptive reuse of HB. This schema will help the user to check whether they fulfil HB-related features among the inclusive ARM and ERS criteria and sub-criteria (Figure 7).

If the majority of the mutual features exist in an adaptive reuse project, then the process for applying the green certification can be envisioned for an adapted HB. If there are insufficient number of criteria fulfilled in an adaptive reuse project, then PCS can be used in order to develop and revise the project according to the related mutual features, ensuring continuity of heritage significance. The integration of sustainable designs with the conservation of HB will be achieved by sustaining their historic values and authenticity.

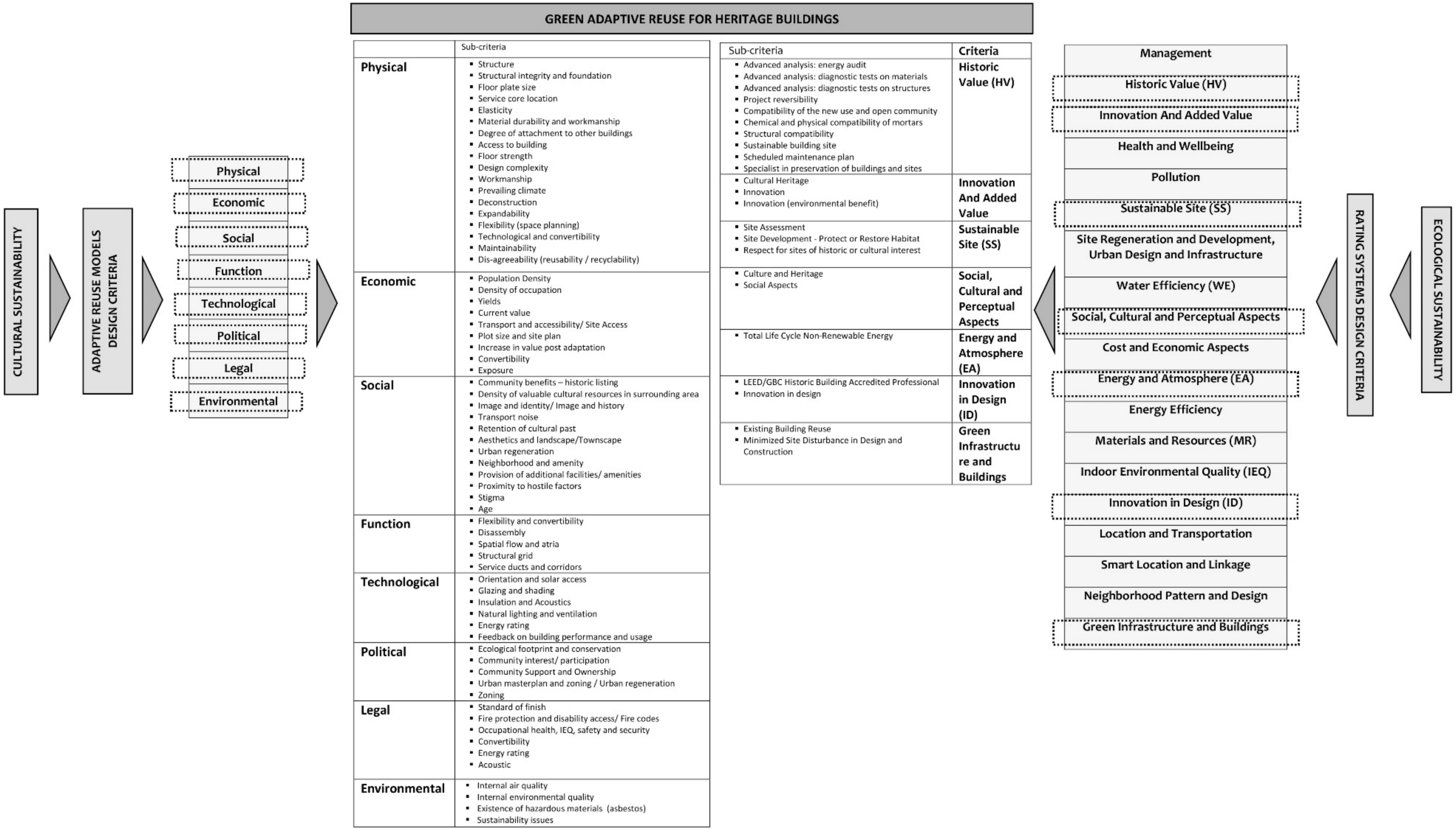

Figure 7. The prerequisite criteria schema (PCS).

4. Conclusions

The identification of historical value must be an integrated part of the refurbishment processes for HB, which are aimed at the preservation and enhancement of all its previous expressions with the ultimate goal of identification, enhancement, and transmission of cultural heritage values to the future generations. Parallel to this, ERS are proposed for improving the historical building's ecological sustainability level without compromising its cultural value. As for the numerous ARM and ERS worldwide, the limitation of this study is that it addresses the ones that are focused particularly on heritage buildings. Moreover, in terms of applying both cultural and ecological sustainability issues to heritage buildings, an examination of criteria and sub-criteria takes place according to the amount of HB obsolescence in ARM and amount of HB analysis in ERS.

As the focus, ARM and ERS consider the features of cultural and ecological sustainability and evaluate HBs according to their interactions. Based on cultural and ecological sustainability roles on heritage buildings, the evaluation structures known as ARM and ERS are capable ways to lead conservators toward green adaptations and standardized assessment processes. Regarding the alignment of mutual features between ARM and ERS, the proposed prerequisite criteria schema (PCS) has the ability to be updated based on future studies following new models and systems.

Author Contributions: Data collection, E.F.; writing original draft, E.F.; conceptualisation, methodology, examination of data, visualisation, framework development, E.F. and Ö.O.T.; writing, review and editing, Ö.O.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data on ARM and ERS have been collected from public sources and have been referred both in the text and in the reference list.

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

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