Sustainable Architectural Design of the Central Mediterranean

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Abstract: The climate of the central Mediterranean archipelago of Malta is characterised by hot dry summers and cold humid winters. For centuries, the architecture of these geoheritage islands, erected in the local limestone, has addressed the physical characteristics arising from the topography. This industrial mineral, the source of dimension stones for the building construction industry since time immemorial, is being depleted at a rapid rate.

The Islands have a significant stock of buildings which, due to growing public awareness, development planning policies and central government initiatives for heritage protection, are being restored, conserved and re-used. This paper explores contemporary sustainable residential architecture completed in recent years in existing urban contexts from environmental, technical and financial perspectives. Adopting a holistic approach to architectural design, bioclimatic and passive considerations would enhance the environmental quality of the existing built environment. Integrating them in the redevelopment through modifications and extensions to existing buildings in order to meet contemporary habitable standards rather than demolishing and developing new residential developments proved to be a viable option from all three perspectives. The resulting sustainable design solution optimizes on energy and land resources through minimising the impact/s on the natural environs which future generations will be enjoying. In addition to having healthier interiors, a prerequisite for the human wellbeing of users, such an approach is financially more remunerative. Based on case studies, this study concludes that energy site sensitive environmental design decisions integrated in existing residential properties is a secure socio-economic investment in the built heritage. The re-designed modifications and extensions are not only sustainable in terms of thermal and natural lighting but also in terms of building materials and construction techniques.

Keywords: sustainable design, bioclimatic design, passive design, Central Mediterranean, Malta

Introduction

Sustainable architectural design optimises natural and energy resources and addresses the wellbeing of citizens. It promotes quality of the indoor and outdoor environments by reducing the negative aspects on same (Iwaro and Mwasha, 2013). A widely held working definition of sustainable development is the one included in the report of the Brundtland Commission which was chaired by the Norwegian Prime Minister Gro Harlem Brundtland (Redclift, 2009; Petrovic et al, 2010; Petrovic et al, 2011a; Petrovic et al, 2011b; Radojicic et al, 2012; Sobczyk, 2014; Mortada, 2016). It defines sustainable development as a "… development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission of Environment and Development, 1987). Environmental, economic and social aspects, all impacting on health and the wellbeing of society, must all be considered and integrated in such a development (Hendriks, 2001; Radojicic et al, 2012). Sustainable development entails a transgenerational perspective focusing on the impact on being and the welfare of each citizen (Dragomirescu and Bianco, 2017).

Sustainable architecture creates and sustains a healthy, energy efficient, built environment, thus optimising on natural and renewable resources (Lányi, 2007). Worldwide architecture accounts for 40-50% of waste generation deposited in landfills and 50% of all the raw materials extracted from the earth surface by weight (Wines, 2008). Sustainable architectural design is an approach of designing the built environment in conformity with the principles of socio-economic and ecological sustainability (McLennan, 2004).

Several recent studies on sustainable design were published (e.g. Soflaei et al, 2017a; Mortada, 2016). This paper explores from environmental, technical and financial perspectives contemporary sustainable residential architecture design from the Maltese Islands completed in recent years with respect to a residential unit in Żabbar and Nadur on Malta and Gozo respectively (Figure 1).

(a) (b)

Figure 1. The Maltese Islands (a) and orthophotos: locations of case studies are circled in red (Source: Planning Authority, Malta) (b).

The Maltese archipelago

Contextual background

Malta is the main island within the Maltese archipelago, a group of islands covering 316m^2 and located almost at the centre of the Mediterranean, circa 100km south of Sicily and 300km north of Libya (Figure 1). The second largest island is Gozo. The climate is typically Mediterranean with mild, wet and humid winters and warm to hot dry summers (Mitchell and Dewdney, 1961; Chetcuti et al, 1992; Schembri, 1997). The islands are generally sunny with occasionally high winds. The mean temperature is the warmest in Europe: circa 23°C and 16°C during the day and at night respectively. Large fluctuations are rare. The typical daytime temperature in the shade is, on the low side, 12^{o}C in winter and, at the highest end, 34^{o}C in summer. At night the temperature may respectively be 7^{o}C and 24^{o}C (Galdies, 2011). With respect to daylight hours, the shortest amount is around 10 whilst the longest is around 15, whilst sunshine hours which total to circa 3,000 annually are at a mean of over 5 hours and 12 hours in the winter and summer months respectively. Mean yearly precipitation is around 600 mm: heavy showers occur generally in autumn and winter (Galdies, 2011).

Traditional, notable vernacular, architecture of the Maltese Islands is a response to this climate. Its architectural and building history evolved through the various occupations through its political history (De Lucca, 1993), the last being Britain (1800-1964). Yet, the rural and urban texture of the Islands is more akin to the Middle East; residential architecture is typically inward-looking with organic patterned urban winding streets and alleys (Bianco, 2016). The traditional residential typology of Malta prior to the advent of the British was the courtyard house. It is the urbanized version of the rural 'razzett', a farmhouse cubic in massing. This rural typology recalls the building forms along the southern Mediterranean basin and suggests the source of the tradition prior to the arrival of the Knights of the Order of St John (1530-1798) (De Lucca, 1993). Despite the influences from Europe, notably Sicily, the word for 'open-air market' and for 'square' are 'suq' and 'misraħ' recalling Semitic origin albeit the romance word 'piazza' is also used.

Vernacular architecture is humane, pragmatic and addresses the wellbeing of the users (Bianco 2016). It comprises of "... dwellings and other buildings of the people. Related to their environmental contexts and available resources, they are customarily owner- or community-built, utilizing traditional technologies. All forms of vernacular architecture are built to meet specific needs, accommodating the values, economies and ways of living of the cultures that produce them" (Oliver, 1997). It is "architecture of the people, and by the people, but not for the people" (Oliver, 2003), a claim supported by the global survey of vernacular architecture published by Noble (2007). It is sustainable in terms of durable, low-maintenance, energy sensitive constructions. The traditional courtyard house so fitting to the Maltese climate was effectively abolished following the introduction of the terraced house typology made mandatory through the sanitary laws and regulations enacted in the latter half of the nineteenth century (Laws of Malta, 1854), the main urban planning legislation until the enactment of the 1992 *Development Planning Act* (Aquilina, 1999). The sustainability of the courtyard model has been the subject of recent publications (Keskin and Erbay, 2016; Manioğlu and Koçlar Oral, 2015; Soflaei et al, 2016; Soflaei et al, 2017a; Soflaei et al, 2017b). The typology of the terraced house, with back gardens and occasionally front ones, is not ideal for the central Mediterranean as it was developed for colder climates where conserving rather than cooling the building is required. Unfortunately this typology was reinforced by Legal Notice 227 of 2016 (Laws of Malta, 2016). "As courtyard houses were replaced by row houses, their introverted centrality gave way to a street-oriented polarity between a symbolic 'front' addressed to outsiders and a functional 'back' for family life. …. The Middle-Eastern perception of the street as no-man's land between intensely private domains was replaced by the baroque perception of the street as theatre" (Tonna, 1997). Yet the traditional terraced house is still suitable in terms of low-maintenance building materials and through the use of architecture features to cut down on sunlight intake in the summer months.

Traditional construction materials and building techniques

Since the Neolithic period the built heritage of the Malta is a statement of the main industrial mineral of the archipelago, the Lower Gobigerina Limestone (LGL), which outcrops over a significant part of Malta and Gozo (Bianco, 1995). It is the oldest member of the Globigerina Formation, a Miocene carbonate sedimentary limestone of shallow marine origin. The characteristic honey-coloured dimension stone, the medium in which the rich architectural legacy of the islands is realized, is extracted from this formation.

Traditional building construction in line with the nineteenth century legislation has a number of significant considerations. These include the following:

1. Walls, effectively in LGL dimension stones, are either single or double-skin. The latter has a wide cavity resulting in an overall thickness of just less than 2 feet (60.96cm) for walls exposed to the elements thus the outer skin will serve as an environmental skin against rain and sun. This was enforced especially for habitable rooms;
2. The floor to ceiling height for habitable rooms was set at a minimum of 2.7m although effectively it varied between 3.0 and 3.3m;
3. Introducing of damp proof course; and

4. Well for rain water collection from the roof; water from backyard was to be drained onto the public street.

This legalisation was implemented in toto for constructions post 1880. Prior to this legislation, walls were also either single or double-skin. Instead of bonding them via a bond stone, they were infilled with inert construction rubble and had an overall thickness of circa 3 feet (91.44cm) (Quentin Hughes, 1967), the minimum being 2.5 feet (76.20cm) (Tonna, 1997). As damp proofing, the lower courses up to circa 1.2m above the level of the ground were constructed in the harder Coralline Limestone which is less absorbent than LGL (Bianco, 1999). Due to shortage of timber the lower floors were roofed over by LGL roofing slabs ('xorok') supported by LGL masonry arches. The ribs were supported by double-skin walls to take the side thrust of the arch (Mahoney, 1996). This type of construction method was still used following 1880. Given that timber beams were more available, and later steel beams, they were used at ground floor level as well. Reinforced concrete roofs were introduced in the 1950s (Tonna, 1997).The mode of tiling had not changed much in residential architecture until the later part of the twentieth century.

Roofs in Malta are traditionally flat. They are constructed similarly to the other floors with a 3 to 4 inches (7.6 to 10.32cm) layer of limestone chippings laid to uniformly distribute the load on top of which another 0.25 inches (6mm) layer of fine chippings with lime-cemented pottery shards was added (Quentin Hughes, 1967; Tonna, 1997). The layer had a slight incline for rain water runoff to drain to a well for storage for potable use. In vernacular residential architecture the well used to be in the courtyard; in nineteenth century terraced houses it was located in the internal yard whilst and for inter-war houses it was placed in the backgarden. Although still compulsory at law, contemporary developments are doing away with wells and instead they drain rain water either directly onto the public street or to the public sewer, both are unsustainable solutions.

Methodology

Two residential units whose building footprint predated 1880 were studied. Both won an international award of the International Academy of Architecture for innovation in traditional architecture:

1. house at 20, Misraħ is-Sliem, Żabbar, Malta (WGS84 coordinates: 14.577169, 35.874464), hereafter referred to as Żabbar House (Figure 2a, b and c) and
2. house at Triq il-Knisja corner with Triq Piju Cellini, Nadur, Gozo (WGS84 coordinates: 14.292030, 36.038399), hereafter referred to as Nadur House (Figure 2d, e and f).

The re-designed modifications and extensions to both tenements for contemporary residential use were undertaken in 2000 and 2012 for the Żabbar and Nadur house respectively (Figure 2). Both were originally substandard for habitation. Although located in a pedestrian space within the village core, the two-storey Żabbar House could not be sold due to its sheer size and condition. Both levels are constructed in traditional masonry blocks roofed over by masonry roofing slabs supported by timber beams (Figure 2a). In terms of contemporary development planning policies, the height limitation for urban conservation area (UCA) is limited to two floors and a washroom at roof level. A case was made with the planning regulator for an additional floor in line with other building heights and uses of properties bordering the misraħ. The architectural work involved alterations and extension (Figures 2b, 2c and 3a) (Anon, 2013). The philosophy of restoration and rehabilitation applied complies with the *Teoria del Restauro* of Cesar Brandi (1963).

The Nadur House is located just outside the UCA. As per local development planning policies, the allowable height is limited to three floors plus penthouse and a three metre front garden along one side of the site (Malta Environment and Planning Authority, 2006). Originally it was a dilapidated one-storey masonry structure, essentially a ruin forming part of a razzett with later post Second Wold War additions erected in poor masonry construction (Figure 2a). The redevelopment utilizes the notion of the ruin and memory as the main basis of its design (Gauci, 2009). Rather than opting for a block of apartments in a saturated neighbourhood, the design involved the restoration and integration of the ruin in the extension of the house (Figures 2e, 2f and 3b).

(a) (d)

(b) (e)

(c) (f)

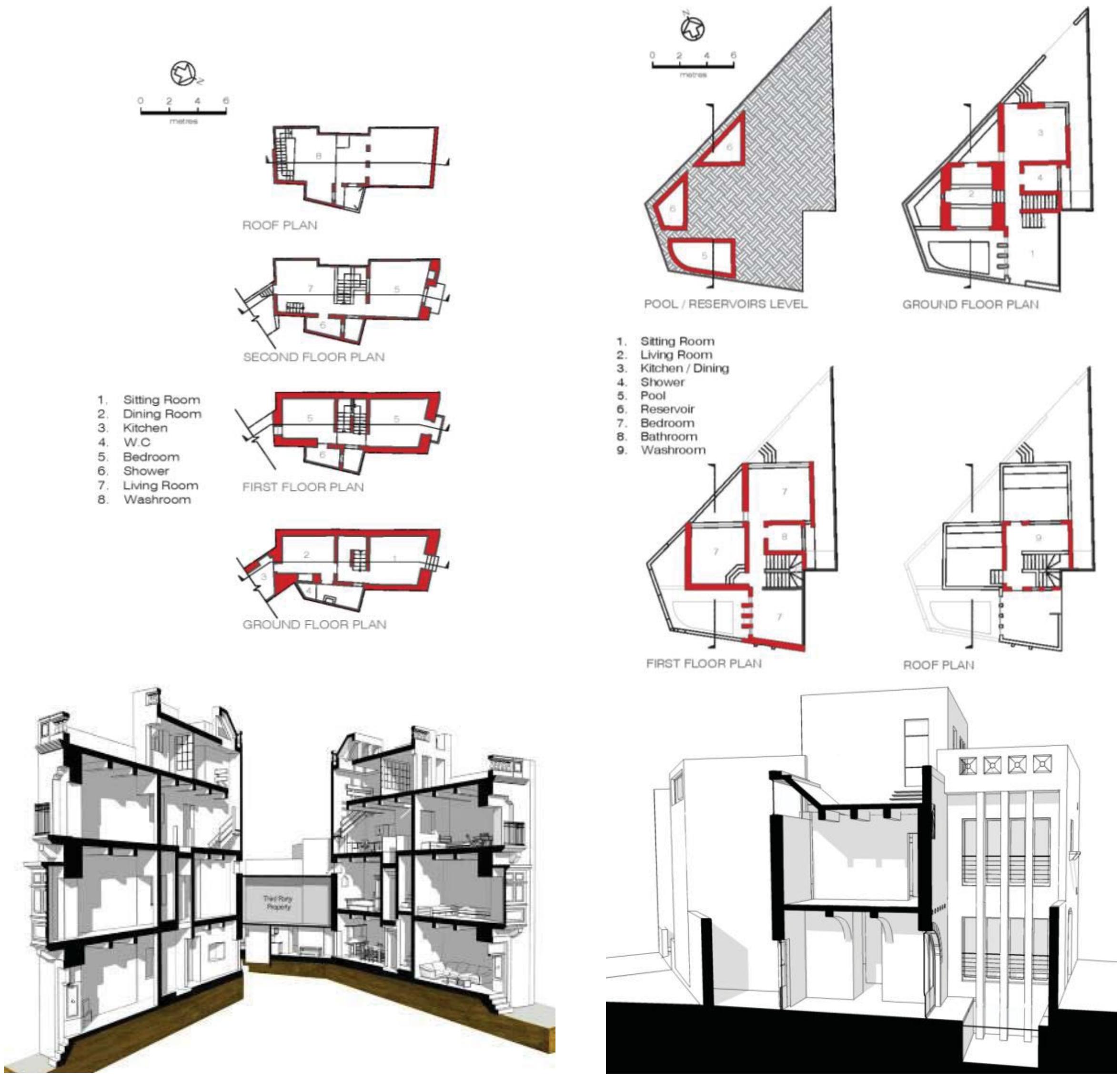
Figure 2. Żabbar House: before (a) and after (b and c); Nadur House: before (d) and after (e and f).

The massing of the Nadur House recalls the vernacular Maltese farmhouse. The general characteristics of the renovated residential units are given in Table 1. In this study, these two houses were

i. evaluated for the sustainability in their re-design as per Wilhide (2002) and Keskin and Erbay (2016); and
ii. assessed with respect to the costs involved in the construction of modifications and extensions in traditional materials and methods and finishing of same to contemporary habitable standards.

Similar costings as (ii) above were undertaken with respect to each site assuming that the house where to be demolished and erected to the allowable height limitation as per development planning policies, sanitary engineering legislation and contemporary building construction and materials which makes use of single-skin walls of concrete blocks roofed over by reinforced concrete slabs.

There are various schools of thought on how the cost-value of a given immovable property is estimated. The method used in this study is based on the cost of constructing and finishing.



(a) (b)

Figure 3. Layout and sectional perspective: Żabbar House (a) and Nadur House (b).

Table 1. General characteristics of renovated traditional residential units.

Characteristics	Żabbar House	Nadur House
Settlement	Rectangular plot with the shortest side overlooking the misraћ is north facing to optimise daylight; the number of small apertures on the south wall is low to block sunlight; no apertures on the east and west third parties walls	Site is a triangular corner; orientation of the dwelling is such to minimise sunlight whilst maximising daylight and air convention currents; a 2m high perimeter wall to property is present
Planning layout	Living spaces are at ground floor level whilst bedrooms, including another family living room, are at the upper levels	Living spaces are at ground floor level whilst bedrooms are at the upper level
Built form	Form is compact with the upper level stepped back from the main elevation to minimise visual impact	Compact cubic form recalling the vernacular architecture of the Maltese Islands
Site impact	Although the resulting dwelling is on three-storeys, the building heights around the misraћ vary; retaining the original colour helped to complement the character of this part of the square. The external masonry walls of the additional level are left unrendered	The building integrates with the existing urban environment in terms of scale; its massing, fenestration and features, most notably the sundial, render it a landmark to the neighbourhood

Results and discussion

The analysis of the architectural design, construction materials and methods used in both the Żabbar House and the Nadur House is the given in Table 2. The interventions undertaken are in conformity with planning and sanitary regulations; thus the tenements were upgraded from substandard to residential units fit for habitation. Furthermore, in both cases, the number of residential units was not increased and thus there was no increase in the density of dwelling units with no corresponding increase in car parking provisions.

A comparative valuation of the properties based on the cost of construction and finishes and the current market values of same as per website http://www.propertymarket.com/ is given in Table 3. The values of the Żabbar House and Nadur House are compared to the values of properties on same respective sites if demolished and rebuilt as per contemporary widespread practice. The computed valuation is based on (i) the current values for land within the limits of development, (ii) the cost of building construction, including demolition, excavations and carting away, (iii) the cost of mechanical and electrical systems (M&Es) and (iv) the cost of finishes. The rate for traditional materials and construction is circa 25% higher than the standard rate. Also, given the site configuration and the required setback at law from street elevations, neither a penthouse nor a washroom may be erected at the Nadur site. Due to the site location of the Żabbar House and Nadur House the cost of the land is respectively 50% and 100% higher than the base rate of €400.00/m^2.

Comparing the valuation of the properties based on the cost and finishes with the market values of similar tenements, the percentage tolerance indicative of the financial risk involved was established. The option of demolishing and re-building the sites as per allowable local planning policies in contemporary materials and construction is less secure.

Redevelopment of substandard and/or derelict buildings and sites instead of demolition is viable. Beyond the indicator model to determine the revitalisation of derelict property proposed by Zavadskas and Antucheviciene (2006), the Żabbar House and the Nadur House illustrate an aspect of sustainable architecture beyond re-using and recycling of traditional building materials. Applying an integrated approach to architectural design within UCAs has not only environmental and technical significance but also a financial merit.

Table 2. Energy design efficiency and building methods and materials.

	Żabbar House	Nadur House
Energy design efficiency	1. North lights at roof of washroom serve as light scoop; pivot windows ensure a breeze in the summer months through air convention currents through the upper levels of the house which have a roof and third party walls facing east and west exposed to the elements 2. No windows opening onto south facing wall 3. Internal shaft creates stack effect 4. Roofs to original bedroom have internal ambient temperature	1. The corner of the plot is west facing: all apertures facing this direction are narrow to cut down on heat from the low lying sun 2. North facing, high level windows at the upper level with pivot type apertures serve as light scoops thus maximising daylight, eliminating sunlight and encouraging air circulation at this level whose roofs are exposed to the elements 3. South facing openings are deep in section to cut down on the sunlight during the summer months 4. Cross-ventilation is provided by apertures facing one another
Building materials	1. All works were undertaken in traditional construction except for the roof to the washroom as the floor to ceiling height imposed by the planning regulator did not allow for timber beams to be used 2. Original walls are thick thus having high thermal capacity; such walls were used in the main elevation of the additional floor 3. Original construction materials used in the stairwell to roof were reused in the new floor 4. Dimension stones for additional construction were traditional but not recycled 5. Recycled timber beams and masonry roof slabs were used	1. Dimension stones from the demolished rooms were re-used in the construction 2. Other building materials are all traditional but none are recycled 3. Construction waste removed from the site comprised roofs of derelict rooms erected in the latter part of the twentieth century and excavation material from the swimming pool; the latter, a source of concrete aggregate, was transported to a local crusher for aggregate production

Table 3. Comparative valuation of property based on cost of construction and finishes.

	Żabbar			Nadur		
	Traditional House		Option to rebuild	Traditional House		Option to rebuild
	Existing	Extension		Existing	Extension	
Area (m^2)						
site	44	44	44	164	164	164
Front garden	0	0	0	75	0	58
Back garden	117	0	117	0	0	0
Buildable levels above ground	106	53	106	23	152	318
Washroom	0	26	25	0	23	0
Basement	0	0	44	0	0	164
Pool/reservoirs	0	0	0	0	35	0
Site cost (in €)						
Buildable levels[a]	63600	47400	105000	18400	140000	385600
Front garden [b]	0	0	0	15000	0	11600
Back garden [b]	11700	0	11700	0	0	0
Cost of works (in €)						
Demolition/ excavation/carting [c]	0	0	6000	0	500	2300
Construction [d]	15900	11850	21000	3450	26250	57840
Pool/reservoirs [d]	0	0	0	0	4200	0
Cost of M&Es (in €)						
Buildable levels above ground [e]	8480	6320	10480	1840	14000	25440
Basement [f]	0	0	1760	0	0	6560
Pool/reservoirs [f]	0	0	0	0	1400	0
Cost of finishing (in €)						
Buildable levels above ground [g]	21200	15800	26200	4600	35000	63600
Basement [h]	0	0	4400	0	0	16400
Pool/reservoirs [h]	0	0	0	0	3500	0
	121147	81493	182476	43552	221724	553644
Total value (in €)		202640	182476		265276	553644
Market value (in €)		240000	160600		293000	525000
% Tolerance		16	-14		9	-5

[a] €400.00/m^2; [b] €100.00/m^2 (0.25*€400.00/m^2); [c] sum; [d] €120.00/m^2; [e] €80.00/m^2; [f] €40.00/m^2 (0.5*€80.00/m^2); [g] €200.00/m^2; [h] €100.00/m^2 (0.5*€200.00/m^2)

Sustainable architectural design has to address the real-estate market but also the socioeconomic realities of Malta (Bianco, 2016). Climatic conditions, natural energy and building resources utilised, and compatibility with site topography are common characteristics of such a design. Akin to vernacular architecture whereby human-nature relation is resolved in elementary, effective and functional manner (Keskin and Erbay, 2016), the Żabbar House and the Nadur House address the prevailing existing environmental conditions, whether daylight, sunlight and/or thermal capacity of the building materials thus leading to less utilisation of energy resources and lower utility electricity bills related to heating and lighting. The orientation of the buildings is dictated by the existing layout of their respective footprint. In the terraced houses of Malta, the ideal orientation is north-south; the east-west axis should be avoided and windows facing in either direction should be kept small (Cutajar, 1989). At Żabbar House the orientation complies with such an arrangement. In the case of the Nadur House orientation went beyond passive design, the traditional solution used for thermal conform and daylight levels. The redevelopment evokes the site, its memory and its location in time and place. From a technical perspective, the resulting buildings are high in endurance; traditional materials and construction are low maintenance, durable, weather well and have nil fire-loading. Such building materials and engineering lead to lower insurance premium.

Malta has the highest population density amongst EU Member States (European Commission). It has a significant stock of empty residential units (National Statistics Office, 2014). New real-estate development of apartments within UCA impacts on the urban infrastructure. Demolishing existing units and constructing a new block of apartments at a given site increases the density of residential units and the corresponding augmentation in car parking provisions.

The analysed houses illustrate sustainable architectural design based on the comprehension of the anatomy of a given building on site. The interventions are in local materials and methods and respecting the climatic parameters of the site, aspects acknowledged for their significance in traditional architecture (Özmehmet, 2005; Keskin and Erbay, 2016), and prove that such interventions are financially viable. The contemporary practice of demolition and construction new residential developments is a less secure investment in monetary terms than opting for a traditional heritage sensitive design. This challenges the popular perception that it is more financially rewarding to demolish and re-erect a new building especially within UCA. Furthermore, given that these houses were recipients of international design awards, their inherent financial value is augmented, thus increasing the tolerance in monetary terms and hence ensuring a safer investment. Long term, they are likely candidates for scheduling which further sustains culture heritage for future generations.

Conclusions

This study evaluates two recent development projects involving traditional houses in the Maltese Islands from environmental, technical and financial perspectives. It concludes that contemporary sustainable architectural design in traditional building materials and construction on existing footprint is a viable option from all these aspects:

1. Environmental:
   i. Integrating bioclimatic and passive considerations in redevelopment through modifications and extensions to existing buildings enhance the quality of the built environment; and
   ii. No increase in the number of residential units and thus no increase in mandatory car parking provisions;
2. Technical:
   i. Use of low maintenance, durable local materials and sturdy load-bearing masonry construction tested through time; and
   ii. Reduction of inert construction waste;

3. Financial:
    i. Modifications and extensions to traditional residential units congruent with the built environment are more secure real-estate investment than demolishing and developing new residential developments; and
    ii. Given that building materials are durable and weather well and the construction is robust, insurance premiums are lower.

Architectural design can transcend the mere compliance with local development planning policy. A sustainable approach aimed at the wellbeing of the occupiers is secured through the use of traditional methods of construction, materials and environmental physics. Site sensitive environmental design with respect to existing residential properties is a socio-economic investment in the built environment.

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