Emirates Journal for Engineering Research, 11(2), 47-58 (2006)

(Regular Paper)

IMPROVING THE SUSTAINABILITY OF LOW-INCOME HOUSING PROJECTS: THE CASE OF RESIDENTIAL BUILDINGS IN MUSAFFAH COMMERCIAL CITY, ABU DHABI

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(Received July 2006 and accepted October 2006)

إنّ التركيز على قضية تحسين استدامة مشروعات البناء لذوي الدخل المنخفض تعد من القضايا المتزايدة الأهمية في الوقت الراهن، كما أن مساهمتها في إضافة قيمة أكبر للمشروعات قد أصبح واضحاً للأعين. إن الهيئات الحكومية التي تعتبر المسئول الأكبر عن عمليات البناء والتشييد عامة وعن مشروعات ذوي الدخل المنخفض على وجه الخصوص مطالبة بتسليم مشروعات تتميز بالاستدامة من حيث كون تلك المشروعات: تنجز في الوقت المحدد، ذات تكلفة مناسبة وفعّالة، عالية الجودة، ذات بيئة داخلية جيدة، صيانتها أرخص، متينة إنشائياً، وسهلة الاستعمال. وعلى المدى البعيد يتأكد مطلب التحسين المستمر لعملية تحقيق خفض سنوي في تكلفة ووقت الإنجاز المتوقع لتلك المشروعات. لكي نرتقي بدرجة استدامة مشروعات البناء لذوي الدخل المنخفض فإنه فمن الضروري إجراء تقييم لأداء هذه المشروعات لتحديد نقائصها وعيوبها لأخذ الإجراءات التصحيحية المناسبة التي تمكّن الهيئات الحكومية من تحسين أداء المشروعات القائمة فضلاً عن المشرعات الجديدة. لتحقيق هذا المطلب، تحاول هذه الورقة إنجاز ثلاثة أهداف رئيسية: أولا: اقتراح مجموعة من المؤشرات الرئيسية التي يمكن أن تستخدم لتقييم أداء المشروعات. سينجز هذا الهدف من خلال مراجعة الأدبيات فيما يتعلّق بمفهومي "تقييم أداء المباني" و"تحقيق الاستدامة في البناء"؛ ثانياً: اختبار مؤشرات تقييم الأداء المقترحة في تقييم أداء عدد من المباني القائمة بالفعل، ولإنجاز هذا الهدف سيتم إجراء دراسة ميدانية على عينة مكونة من 36 مشروع لذوي الدخل المنخفض أنشأتها حكومة الإمارات العربية المتحدة في مدينة "المصفح" بأبو ظبي. أخيراً: تلخيص الدروس المستفادة ووضع عدد من التوصيات المفيدة للهيئات الحكومية وللمهتمين بقضايا البناء لذوي الدخل المحدود فيما يتعلق بكيفية تحسين أداء المشرعات المشابهة المزمع إنشاؤها في المستقبل.

The focus on improving the sustainability of low-income building projects is increasing and its contribution towards adding more values is becoming visible. Government authorities responsible for the construction process need to deliver sustainable buildings in terms of being: on time, cost effective, high quality, good indoor environment, durable, cheaper maintenance, and user friendly. On the long run continuous improvement to achieve year-on-year reduction in project cost and time is expected to be accomplished. In order to improve sustainability for low-income building projects, it is necessary to assess the performance of these buildings to identify their deficiencies and faults to take corrective actions and enable government authorities improve the performance of new projects. Towards this aim, the paper attempts to accomplish three main objectives: First, to propose a set of Key Performance Indicators to Assess Building Performance (KPI_ABP). This objective is achieved through the review of literature related to assessing building performance and sustainable development in construction. Second, to test the proposed KPI_ABP set in assessing the performance of actual buildings. To achieve this objective, a field study is carried out on a sample of 36 low-income buildings projects constructed by the Government of the United Arab Emirates (UAE) in the city of Musaffah, Abu Dhabi. Finally, to outline learned lessons and recommendations useful to government authorities and construction professionals as to how to enhance the performance of new low-income projects.

Keywords: Assessing Building Performance, Sustainability, Low-income Building Projects, Construction Management.

1. INTRODUCTION

Often, clients and end-users of low-income building projects complain that their accommodations or workplaces are not designed so as to suit their requirements and meet their expectations. Controversially, building designers assert that their designs have carefully considered the client needs and accommodated all of the specified requirements. Unfortunately, the problem is often one of misunderstanding on both

sides. It is true that the designers have comprehensive knowledge of building design but usually receive little or no feedback after the building is completed. Today building technologies are progressing rapidly and buildings became more complex and sophisticated and hence their impacts on environment, society and economy are greater. New constraints such as efficient resource usage and low environmental impact require innovative sustainable solutions. Sustainability has become a valuable issue in developing building projects, yet more vital in the case of low-income building projects. Sustainability is achieved when a building maintains qualities such as its being: delivered on time, cost effective in both short and long runs, high quality, good indoor environment, durable, cheaper to maintain, and user friendly.

1.1 Research Aim and Objectives

The aim of this paper is to propose an approach to assess the performance of already built low-income building projects so as to save designers and government authorities from repeating practices proven unsatisfactory. This aim is achieved through accomplishing three objectives:

- First, based on a review of literature related to assessing building performance and sustainable development in construction, the paper proposes a set of Key Performance Indicators to Assess Building Performance (KPI_ABP).
- Second, based on a field survey carried out on a sample of 36 low-income buildings projects constructed by the Government of the UAE in the city of Musaffah, Abu Dhabi, the paper tests the proposed KPI_ABP set in assessing the performance of actual buildings.
- Finally, based on the results derived from objectives one and two, the paper outlines some learned lessons and recommendations useful to government authorities and construction professionals as to how to enhance the performance of new low-income projects.

1.2 Research Methodology and Case Study Sampling

The aim and objectives outlined above called for a research strategy, which could gather data sufficiently rich to enable clients and construction professionals assessing building performance as an approach to improve the sustainability for low-income building projects. Two research methods were employed, namely literature review and case studies. The literature review was used to (1) review the assessment of building projects and sustainable development in construction, (2) proposing Key Performance Indicators (KPI) to be used in assessing building performance. The literature review depended on textbooks, professional journal and magazines, conference and seminar proceedings, dissertations and theses, organisations and government publications as well as Internet and related websites. The second method was a field study carried out on 36 construction projects to assess their performance according to the proposed indicators. Analysis of case studies was presented as learned lessons and recommendations for enhancing the performance of new low-income projects. Each case study comprised a detailed inspection of project files to collect information about building history, design and construction defects, users' modifications, as well as clients and users complaints database. A survey questionnaire, site visits and unstructured interviews were held with a sample of clients, end users, building architects designers and maintenance contractors in order to assess building performance and investigate the operation and occupation problems. Using more than one source of evidence (project documentation, complaints database, questionnaire and interviews), improves the validity of the collected data and increases background knowledge. In an effort to ensure the reliability of the data, data collection and questioning concentrated on facts and events, rather than highly subjective interpretations [1, 2].

The objective of case study sampling is to select a representative and non-biased sample of construction projects from which to assess the performance of low-income buildings and as such to test the KPI_ABP. The survey was undertaken in the city of Musaffah, Abu Dhabi, United Arab Emirates. Information about distribution of the surveyed projects was collected from the Department of Social Services and Commercial Buildings, UAE. The city was divided into 3 sectors: Musaffah East-10 (ME-10), Musaffah East-11 (ME-11), and Musaffah East-12 (ME-12). The total number of buildings in these sectors was 673 buildings [3]. A systematic sample of 36 buildings (1:19) was used to select the case study sample. This sampling methodology effectively covered the surveyed city, so the assessment of low-income building projects were extracted from different projects constructed in different sectors, with different client structures, cost, time and quality, as well as used by different users, all of which enhanced the reliability and validity of the collected data and lessons learned.

2. A BREIF DESCRIPTION OF THE UAE: THE STUDY LOCATION AND THE CONSTRUCTION INDUSTRY

The United Arab Emirates is a federation of seven emirates, namely Abu Dhabi, Dubai, Sharjah, Ajman, Umm Al Quwain, Fujairah and Ras Al Khaimah. The total area of the country is about 83.600 square kilometers. The UAE is situated in the south-east of the Arabian Peninsula, north of the equator, between latitudes 22 degrees and 26.30 degrees to the North, and longitudes 51 degrees and 56.30 degrees East of Greenwich mean time (GMT). It extends from the Sultanate of Oman in the East to Qatar in the West and Saudi Arabia in the South. It lies along the southern

coast of the Arab Gulf stretching for 700 kilometres. Its eastern coastline stretches for 90 kilometres along the Gulf of Oman.

The United Arab Emirates is one of the best world winter resorts. Several millions of tourists visit the country every year. Between November and March, it experiences warm sunny days with an average temperature of about 26°C and cool nights with an average temperature of about 15°C. High temperatures (up to 49°C) and high level of humidity are the normal between June and August in several main cities. The population of the UAE was estimated to be 2,563,000 million in 2005. 85% of the UAE populations are urban. The population of the United Arab Emirates is concentrated primarily in cities along both coasts [4]. The Emirate of Abu Dhabi occupies 67.000 square kilometres of the country's total. Abu Dhabi is the federal capital of the UAE being the largest, most populous and richest in oil. Figures (1) and (2) show the location of the UAE [5].

2.1 The City of Musaffah

The city of Musaffah is located 40 km from Abu Dhabi. It is divided into two main sections: Musaffah Industrial City and Musaffah Commercial City. The first city is designed to be an industrial base to Abu Dhabi. It contains a number of factories, workshops, establishments and Musaffah Port. The commercial city is constructed by the Government of the UAE to accommodate the low-income worker of the industrial city. The case studies used to assess building performance are selected from the buildings in Musaffah commercial city. These projects consisted of ground floor (entrance, shop, watchman room, and service rooms), three typical floors (4 two bed room flats), and the last floor (roof area & service rooms). Two types of Air Conditioning (A/C) systems are used: window type and central type. The average cost of each building was around 3,000,000 Dirhams Arab Emirates Dirhams (AED), where (1 USD = 3.67269 AED) [5].

2.2 The Construction Industry

Since the establishment of the UAE, the federal government used the country's oil wealth for the country development and upgrading the life of citizens, thus making huge achievements in a very short time. Successive plans for sustainable development have been implemented for the establishment of hundreds of projects for modernisation, development, services provision, setting up of residential towns, modern metropolis, building hospitals, clinics and health centres, schools and universities. Huge projects have also been carried out for the construction of necessary infrastructure, roads and bridges and tunnels, provision of electricity and water, communications and telecommunications and other basic services, thus making the UAE in par with developed nations.

Figure 1. The Geographic Location of the United Arab Emirates [4].

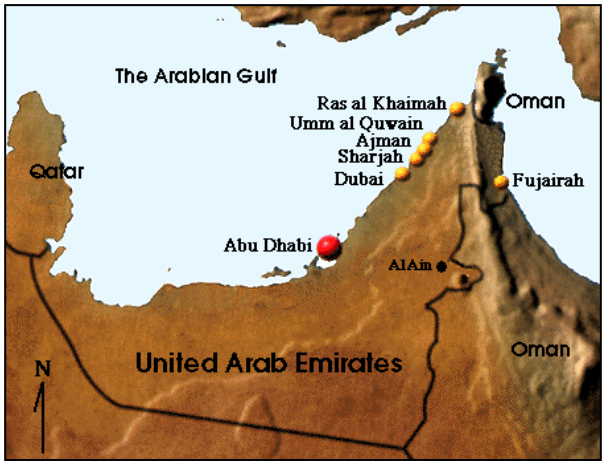

Figure 2. The Map of the United Arab Emirates [4].

The most important source of funding for construction projects in the United Arab Emirates is the budget allocation by the federal government to finance development projects. This tends to be the case in all other members states of the Gulf Cooperation Council. These projects include road building, bridges, drainage and sewerage, public building, and low income housing projects. In the Emirate of Abu Dhabi, there is another source of finance available for commercial and low-income building projects. This is run by the Department of Social Services and Commercial Buildings (DSSCB) [6]. Since the case studies used to test the assessment of low-income building projects were projects executed by the DSSCB, the following section will give a brief description of the department, its objectives, the execution steps of the commercial and low-income building project and the department achievements.

2.3 The Department of Social Service and Commercial Buildings (DSSCB)

The Department of Social Services and Commercial Buildings is the authority responsible for the construction of commercial buildings in the Emirate of Abu Dhabi. It is playing a pivotal role in the booming and progress of the United Arab Emirates. Its beginning was marked by the setting up of the Building Credit Corporation in 1971, followed by the Committee of Commercial Buildings Supervision in 1976 and integrated with the Department of Social Services and Commercial Buildings in 1981. The department is coordinating and co-operating with other authorities and parties to achieve the highest standards and specification in the construction process[4]. The DSSCB aims to [7]:

1) Improve life standards of citizens by providing them with social insurance, stable income and protection against high interest rates and debts of commercial banks;
2) Offer solutions to housing problem in Abu Dhabi and achieve balance between supply and demand;
3) Support infrastructure projects such as roads, water and electricity;
4) Develop and enhance the construction industry and other economical sectors in Abu Dhabi;
5) Contribute in establishing national design, contracting and maintenance firms and organisations; and
6) Establish architectural development principles and boosting the tourism industry.

The execution of any commercial building project supervised by DSSCB follows specific steps, namely:

1) Getting a preliminary approval from the Crown Prince's court and nominating a qualified consultant by the department to prepare the required design.
2) The department reviews the designs and selects those compatible with the rules and regulations issued by government bodies.
3) The building project is announced in a general tender through the newspapers giving the chance for contractors enlisted in the department to take part in the tender.
4) After the opening of envelopes and the settling of the tender on one of the contractors, the Projects Directorate follows up the execution of the project and prepares weekly and monthly reports on work progress.
5) After the completion of the building the department follows up the one-year obligatory maintenance**,** and then the building goes to the Maintenance Directorate, which pursues the building's maintenance through the announcement of a tender giving the operation to the best bidder.
6) Rentals are made through the Lease Directorate, which manages the building's financial and administrative affairs through renting shops, showrooms, and flats and providing them with the required services.
7) The building revenues are being distributed accordingly to the percentage ratio by the project as follows:
   - The building client will receive 30 % of the building's revenue and 40% of the villa revenue.
   - 60% of the building's revenues and 50% of the villa's revenue are allocated for reimbursing the surety until the mortgage is lifted. The sureties do not bear any interest.
   - The department keeps the remaining 10% for the maintenance work [5, 8].

Table (1) indicates that the value of the projects has increased since the establishment of the DSSCB. The department has completed about 6000 projects at a cost of 30 billion Dirhams. They included about 94000 housing units. Figures (3), (4) and (5) show the numbers of the projects, flats, and costs respectively over years [8, 9].

Table 1. The Development of Projects Executed by the DSSCB

Year	No. of Bldgs.	No. of Flats	Projects cost (Dirhams)	Year	No. of Bldgs.	No. of Flats	Projects cost (Dirhams)
1977	37	472	79,400,000	1989	46	172	51,900,000
1978	135	3268	461,300,000	1990	73	1417	280,800,000
1979	131	2417	513,300,000	1991	108	1969	659,800,000
1980	176	3265	682,200,000	1992	342	5974	1,466,600,000
1981	774	3224	720,700,000	1993	310	6306	2,049,200,000
1982	366	3172	814,200,000	1994	187	5108	1,928,900,000
1983	318	2766	1,109,800,000	1995	313	7838	3,270,500,000
1984	177	2555	845,800,000	1996	495	11306	3,748,200,000
1985	51	1343	494,100,000	1997	545	11047	4,197,000,000
1986	28	797	576,800,000	1998	219	7426	2,769,300,000
1987	268	436	208,500,000	1999	214	6637	2,421,400,000
1988	135	489	148,100,000	2000	154	4210	1,435,900,000
Sub Total	2596	24204	6,654,200,000	Sub Total	3006	69410	24,279,500,000
				Grand Total	6002	93614	30,933,700,000

3. ASSESSING BUILDING PERFORMANCE

Generally, assessing and measuring performance are the processes of checking, monitoring, reviewing and evaluating the short, medium and long-term progress and direction of organisations, departments, divisions, projects, functions, groups and individuals. It is an ongoing process which aims to identify what is going well and why and what is going wrong or could be improved, and why. In addition, corrective actions have to be taken in order to overcome shortcomings and enhance performance. Performance measurement can only be effective if it is carried out against specific aim and objectives [10]. Performance measurement has spread to many industries, including the construction industry. The construction industry is a project-oriented industry where each project is unique and

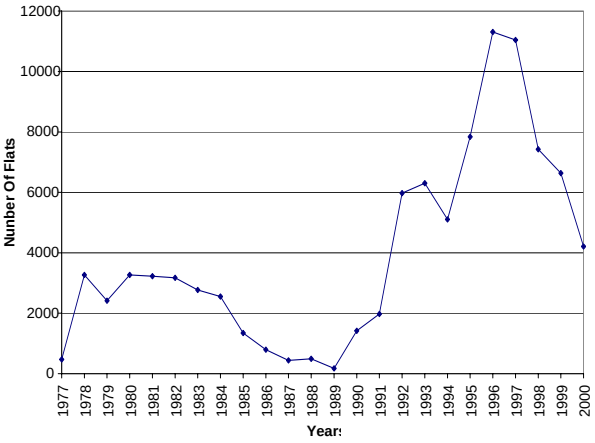

Figure 3. The Number of Projects Executed over Years [4]

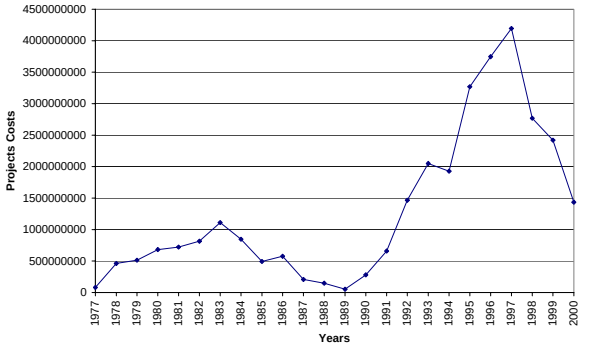

Figure 4. The Number of Flats Executed over the Years 1977-2000 [4]

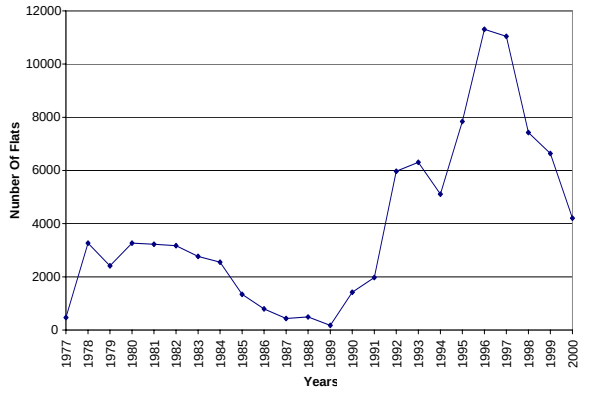

Figure 5. The Costs of the Projects Executed over the Years 1977-2000 [4]

could be considered as a prototype, although a similar set of process stages is involved in every project [11]. In the past, construction projects were typically evaluated informally and in terms of cost, time, and quality [12,13]. This type of evaluation was perhaps sufficient at that time because building projects were relatively less complex and the level of technology in design was low. But things have changed dramatically and the three categories of project evaluation of time, cost and quality have been described as insufficient [12]. Building performance evaluation has to be improved to cope with the ever-increasing proliferation and specialisation in the construction industry in terms of matters such as building types, services, technology, code and regulatory requirements, energy conservation, fire safety, environmental health, and safety constraints. Construction is highly sophisticated industry that has evolved from simple residential homes to complex projects incorporating high technology services and communications. The research and development of new technologies and its introduction into buildings is progressing quickly. Monitoring of these new technologies is necessary in order to compare actual performance with intended criteria, and through this process improvements can be found and incorporated in building design[14].

3.1 The Role and Purpose of Assessing Building Performance

Assessing building performance is an effective tool to record and compare actual performance with explicitly stated criteria. It is an ideal tool and a systematic way to tackle significant problems experienced in building performance with particular emphasis on the perspective of the building users. It could be used for different purposes. For example, it provides an opportunity for clients and facility management team to consult building users. This will improve the relationship for any future cooperative activity and enable building users deliver their problems or dissatisfaction to higher levels. In addition, assessing building performance can be used to assist upgrading of existing facilities. It is often very useful to conduct an assessment before planning for any refurbishment or renovation because users' expectation, requirements and needs are addressed and the design team is properly informed. Similarly, it responds well to users' complaints, dissatisfaction and understanding expectations. However, it is crucial to find out the underlying sources of dissatisfaction before spending money imposing solutions that in the end turn out to have addressed the wrong problem [14].

3.2 Benefits of Assessing Building Performance

Despite its obvious usefulness in understanding current building performance and occupants' requirements, Assessing building performance is an important tool for the management and planning of new facilities. Potential benefits range from short term to long term[15].

1) The short-term benefit of assessing building performance is to allow clients and facility management team have a better understanding of the functionality and performance of their buildings compared with the stated criteria during design. Before improvement can be made, the problem needs to be identified and studied in detail. Active user participation in the evaluation process plays an important role in this respect. As a result user values are confirmed and reflected in the design of new building.
2) The medium-term benefits comprise the use of data collected during the assessment of building

performance to be a source of knowledge for planning new buildings of similar type. Designers equipped with user feedback are helped to design future buildings that more closely meet the needs of the users.

3) In the long term assessing building performance helps establish databases, generates planning and design criteria for specific building types and enables designers to consider documented past experience. This is important to avoid repeating past errors and recognise past success. The accumulated information plays a pivotal role in improving the quality of future buildings and services to the client and users. Assessment results may also improve design practice by making designers aware that their buildings may be subject of scrutiny. Thus design of future buildings may lead to better value for money to clients and society. This concern not only issues of functionality, but overall sustainability, energy efficiency and environmental impact.

4. SUSTAINABLE DEVELOPMENT IN CONSTRUCTION

Sustainable development is defined as development that meets the needs of the present without comprising the ability of future generations to meet their own needs [16]. It is not a new idea. Many cultures over the course of human history have recognised the need for harmony between the environment, society and economy. What is new is an articulation of these ideas in the context of global industries and information society. Sustainable development aims to deliver built assets that enhances quality of life and offers customer satisfaction; offers flexibility and the potential to cater for user changes in the future; provides and supports desirable natural and social environments; and maximise the efficient use of resources [17].

Sustainable construction is a part of sustainable development. Chen and Chambers [18] defined sustainable construction as creating a healthy built environment using resource-efficient, ecologically based principles. Sustainable construction is concerned with three issues: environmental, social and economic. Environmental protection is important because construction represents major contribution to climate change, resource depletion and pollution at both local and global levels [19,20]. Construction needs to consider its effect on society because everything that has or will be built affects the local community. Construction should promote healthy living and socially cohesive communities and respond to any changes in societal expectation. The economic dimension of sustainable construction can be seen from two perspectives. In the one hand, sustainable construction will stimulate growth in the industry which will increase the percentage of gross domestic product and provide more job opportunities [19]. In the other hand, it will increase client's profit and increase investment return[21].

If sustainable construction is successfully accepted and absorbed in developing a construction project, the participants will gain its benefits in terms of cost savings, project schedule compliance, reducing environmental risk and uncertainty, ensuring legislative compliance, improving relations with regulators, improving public image, enhancing employee productivity and improving market opportunity. Good construction practice offers both environmental and economic benefits such as reducing health and safety impacts on staff and local community, reducing liability costs in connection with disposal, reducing remedial work and construction delays. There are also many potential advantages for contractors for demonstrating environmental responsibility: improved opportunity to tender, less money wasted on fines, less money restoring environmental damage, less money lost through wasted resources and the improved environmental profile [22].

To achieve sustainable construction, there should be changes in thinking, behaving, producing and consuming [23]. Miyatake [24] Suggests that in order to achieve sustainability, the industry must change the process of creating the built environment from linear to cyclic processes which will bring increased use of recycled, renewed and reused resources, and decrease in the use of energy and other natural resources. To attain environmentally responsible construction, all practitioners must make a commitment, change their behaviour, adopt new products, ideas and practices, integrated environment system with normal work processes, involve close co-operation of all project participants, starts as early as possible, and be visible throughout the building's life cycle [20].

The focus on improving sustainability for low-income building projects is increasing and its contribution towards adding more values is becoming visible. Sustainability promotes a balanced approach by taking account of the need to continue in business, but does not seek profitability at the expense of the environment or society's needs [25]. Sustainability concerns protecting environmental quality, enhancing social prosperity and improving economic performance[19].

4.1 Sustainability Principles in Construction

The principles of sustainability within the construction industry are:

1) Showing concern for people by ensuring they live in healthy, safe, productive and nature-harmonious conditions.
2) Safeguarding the interests of future generations while at the same time meeting today's needs.
3) Evaluating the cost and benefits of the project to both society and environment.

4) Improving relationships and supply chains to create healthy business environment, promote effective productivity and efficiency.
5) Improving the quality of buildings and services, creating job opportunities, and promoting social cohesiveness.
6) Minimizing damage to the environment and its resources.
7) Assessing risk and uncertainties of any action taken.
8) Using technology and expert knowledge to seek information and improving efficiency and effectiveness.
9) Providing for easy access of information, working within ethics, encouraging participation, respecting and treating stakeholders equitably [26].

5. USING KEY INDICATORS TO ASSESS BUILDING PERFORMANCE OF CASE STUDIES

Government authorities responsible for the construction process need to deliver sustainable buildings in terms of being: on time, cost effective, high quality, good indoor environment, durable, cheaper maintenance, and user friendly. On the long run continuous improvement to achieve annually reduction in project cost and time is expected to be achieved. Once an authority has analysed its mission, identified all its stakeholders, and defined its goals, it needs a way to measure progress toward those goals. Key Performance Indicators (KPIs) are those measurements. The KPIs are quantifiable measurements, agreed to beforehand, that reflect the critical success factors of an organization or a project. They will differ depending on the type of the organization and the project. Whatever KPIs are selected, they must reflect the organization's goals, they must be key to its success, and they must be quantifiable. The Key performance indicators purpose is to enable measurement of project and organisational performance throughout the construction industry. This information can then be used for benchmarking purposes, and will be a key component of any organisations' move towards achieving best practice. There are many frameworks for KPIs. For instance, the Department of the Environment, Transport and Regions, the Construction Industry Board, and the Movement for Innovation through the Construction Best Practice Programmes in the United Kingdom, identified a KPI framework consists of the following indicators: (1) Time, (2) Cost, (3) Quality, (4) Client satisfaction, (5) Change orders, (6) Business performance, and (7) Health and safety [27]. In addition, The Centre for Advanced Engineering (CAE), New Zealand undertaken some research into how best to measure construction industry performance – so that to establish some objective data on how well the industry is doing, and how to allow companies involved in the construction industry to benchmark their performance against the overall industry results. The Centre has produced a set of Key Performance Indicators. They are: (1) client satisfaction-product, (2) client satisfaction-service, (3) predictability cost-design, (4) predictability cost-construction, (5) predictability cost-project, (6) defects, (7) predictability time-design, (8) predictability time-construction, (9) predictability time-project, (10) safety lost time, and (11) profitability [28].

Since the case studies selected to assess building performance are constructed buildings and already in use, the Key Performance Indicators to Assess Building Performance KPI_ABP proposed by the authors will focus on assessing building performance in terms of quality and clients satisfaction. User satisfaction was added to client satisfaction, as many of the building users are not clients. In addition, Maintenance works indicator was added as it expresses and measures the ongoing situation of the interaction between the users and the rented facilities. Details of these indicators are as shown in table (2).

Quality is defined as conformance to an owner or customer product requirements. It is the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs [29]. A quality issue is defined as an issue that affects the project so that work needs to be redone, modified or compromised to a lower standard than originally agreed. Since measuring design and construction defects represent a key issue to assess building quality, a number of measures were identified by the authors to assess the quality of low-income building projects. Clients and users will be satisfied when the finished product meets or exceeds their expectations. In addition, the satisfaction will diminish when the after completion services do not cover the client and user requirements[30], Assessing client and user satisfaction aims to measure how they are satisfied with the final product and followed service. Using maintenance works to assess building performance represents an important KPI. It aims to explore the main problems that face the building and its users throughout the project life cycle. This will enable government authorities and construction professionals avoid such problems in new projects. A Likert scale of 1 to 5 employed to measure the building performance against the stated criteria. Although there are many forms of scaling, the Likert scale was adopted because it is commonly used [31], simple to construct, permits the use of latent attitudes and is likely to produce a highly reliable scale [32].

6. DATA COLLECTION

Different methods used for data collection, namely:

1) A detailed inspection of project files carried out to collect information about building history, design and construction defects, users' modifications, as well as clients and users complaints database.

2) A survey questionnaire was designed to test the KPI_ABP suggested by the authors. The questionnaire divided into three sections to cover the assessment criteria. Section one was intended to be answered by the building architects. The questions of this section were open ended question to get as much information about assessing the quality of the surveyed buildings. Section two was intended to be answered by both, the client and the end users. Section three is intended to be answered by maintenance contractors. The questions of the last two sections were close ended questions and the respondent were asked to rank their answers on a scale from 1-5: where 5= excellent, 4= very good, 3=Good, 2= average, and 1=low, see table2.
3) Site visits were carried out to check up the building maintenance, record current problems and take photograph of the building under study.
4) Unstructured interviews were held with a sample of clients, end users and maintenance contractors in order to assess building performance and investigate the operation and occupation problems. The number of categories to respond to the questionnaire and interviewed as follows: 36 building clients, 72 end users (at a rate of 2 families/building), 15 architects, and the top ranked 3 out of 13 maintenance contractors working in the Musaffah city. A plenty of room was left blank so that respondents of the questionnaire can add information, comment and advice.

Table 2. A proposed check list of Key Performance Indicators to Assess Building Performance (KPI_ABP)

Major Performance Area	Indicator	Sub-indicator
Quality	Design and Construction Defects	Imitating Project brief
		End user involvement in the briefing and design process
		Understanding the users' culture and traditions
		Considering whole project life
		Functional, aesthetic, safety requirements and constructability
		Material Selection
		Construction deficiencies
Client and User Satisfaction	Client satisfaction – product	
	Client satisfaction – service	
	User Satisfaction	
Maintenance Works	Maintaining Sanitary ware	
	Maintaining aluminium, glass and carpentry works	
	Maintaining block work, plastering and painting.	
	Maintaining Flooring and external finishing	
	Maintaining electro-mechanical services	

Figure 6. Damaged Water Tanks

Table 3. Survey Questionnaire Using the Proposed KPI_ABP to Assess Building Performance

Area	Indicator	Sub-indicator					
Quality	Design & Construction Defects	Who imitated the project brief?					
		Have the building user been involved in the briefing and design process?					
		To what extent do you understand the users' culture and traditions?					
		Have you considered the whole project life cycle during design?					
		How do you consider the functional, aesthetic, safety and constructability requirements of the building?					
		How were the building materials selected? And what are the implications of the selected materials?					
		What are the construction deficiencies in Musaffah buildings?					
Client and User Satisfaction		Scale:	1	2	3	4	5
		As a client, how are you satisfied with the finished building?					
		As a client, how are you satisfied with the service submitted by the DSSCB, architect, and maintenance contractor?					
		As a building user, how are you satisfied with the service submitted by maintenance contractor?					
Maintenance Works		How is it easy to maintain sanitary ware?					
		How is it easy to maintain aluminium, glass and carpentry works?					
		How is it easy to maintain block work, plastering and painting?					
		How is it easy to maintain Flooring and external finishing?					
		How is it easy to Maintain electro-mechanical services?					
		Remarks:					

Figure 7. Unused Gas Tank

7. DATA ANALYSIS

Out of 126 questionnaires were distributed, 71 questionnaires were completed and returned. This included 21 clients, 40 end users, 7 architects, and 3 top ranked maintenance contractors, which represents % 56.34 of the overall number of clients participating in the project. All the respondents of the survey questionnaire were interviewed. The results of analysing the collected data of the case studies showed that:

7.1 Quality: Design and Construction Defects

1) All the architects responded to the questionnaire pointed out that the general project brief was initiated by the government authorities, which are responsible for the construction process. This included the number of floors, parking area, number of shops, open to sky dimensions, etc. Detailed project brief which include the number of flats, its contents and specifications is initiated by the client in collaboration with the designer and then approved by the government authorities. All end users claimed that they were not engaged in the briefing and design process. Hence, their requirements were not captured and their needs were not reflected in the building design. Architects mentioned that this could be attributed to the nature of the government and mass production nature of the projects, where the end user is usually absent or unknown during the briefing and design process.
2) Five out of seven architects stated that the users of these facilities came from different background and different cultures. Because of their absence during the briefing and design process, they were not able to explain their requirements and the designer does not have the chance to understand their culture and traditions. Hence, many of the end users have modified the rented facilities to meet their requirements and match their customs, which affected the performance of the whole building and its surroundings.
3) About 85% of the respondents mentioned that the whole project life was not well considered during the design process. This was obvious in the cost of operation and maintenance stages. Selecting un-durable materials resulted in replacing installed items within few years of completion. For example, upper water tanks, which are exposed to external weather, humidity and sunlight, resulted in creating cracks in these tanks and getting nails and metal connection rusted. The whole life of the project was expected to be 25 years, where these tanks became unusable within 3 years of construction. Many of these water tanks are being replaced with isolated plastic panels which are more durable in hot andhumid weather, see figure (6). Furthermore, another discard of the whole project life and represent unnecessary cost is present in fixing and installing facilities and equipment which were not used since these buildings were constructed: such as central gas system and filtration system. This is because tenants preferred to avoid any extra bills that they have to pay, see figure (7).
4) Regarding the functional, aesthetic, safety requirements and constructability of the surveyed buildings, all architects referred that these buildings were designed to be commercial buildings to meet the function and the aim of their construction. In addition, the aesthetic appearance of these buildings were designed by the architect according to the client point of view and then approved by the Heritage Committee in Abu Dhabi Municipality. Respondents mentioned that many design firms used luxury materials such as marble tiles and curtain walls, which resulted in increasing the building cost and the area exposed to sunlight. As a result the Air Conditioning capacity to cool the building has been increased. This increased the amount of the electric bill, which has to be paid by the end user. Adequate safety requirements were provided and checked by the Civil Defence Directorate. Four out of seven architects mentioned that many design firms opted to create complicated façade design to attract their clients and win new ones. It was noticed during the site visits that it was difficult to construct such designs which are not commensurate with low income building projects. Furthermore, poor workmanship resulted in improper fixing of external cladding which led to falling marble tiles causing damages to people and private properties see figure (8).
5) Specifying construction materials was basically done by the architect with the collaboration with client. Project documents include a list of material selection, where the contractor was allowed to select from three materials (equal in price and performance). All architects pointed out that 75% of the surveyed buildings were constructed about 10 years ago. Many of the materials used were imported from abroad, as they were not manufactured in the

UAE at that time. This included glass, kitchen cabinets, sanitary ware, external finishes…etc. The maintenance companies which are responsible for maintaining these buildings referred that any damage happens to an item such as broken glass or damaged sanitary ware resulted in importing materials to fix the damaged items. Recently, these materials are produced in the UAE and new buildings use locally made materials.

6) All architects clarified that there were many defects in the construction of low-income buildings in Musaffah city. These defects emerged from design faults or construction deficiencies. For instance, water leakages represent one of the problems that affect buildings, disturb end users and maintenance contractors. This is attributed to many reasons such as: bad workmanship of fixing sanitary ware and sewerage pipes, hiding the pipes in concealed ducts which make the process of following water leakages a difficult task, see figure (9). Wet areas such as bathrooms and kitchens were built above electric rooms.. So, any broken pipe will leak on electric room, which in some cases resulted in electric short causing danger to tenets. In addition, areas of service rooms are not sufficient to allow the electro-mechanical contractor performs required maintenance work. This delays repairing affected parts or changing damaged sets, see figure (10).
7) According to the Municipality and Town Planning Department regulations, the dimensions of the Open To Sky (O.T.S.) service duct is 2.00m X 2.00m. This is to ventilate kitchen, bathrooms and toilets. Site visits showed that these ducts were used to pass Air Conditioning ducts to the flats. The dimensions of A/C Duct are about 0.60m X 0.60 m. The O.T.S, which contain all these installation of sanitary pipes and A/C ducts make its maintenance a big trouble particularly if a sewerage pipe is broken.
8) Remarkable changes to the building design were done by clients by transferring the parking area to shops and flats to meet the increasing demand for low-income building. Such modification is not considered in the building design in terms of electric load, water tanks capacity and city services. Furthermore, needless to say that in few buildings, the service rooms were used as accommodation, see figure (11).

7.2 Client and User Satisfaction

1) A number of 15 clients out of 21 have an average satisfaction with their finished buildings with a rate of 2.75 out of 5. Although they have briefed their requirements to the design firm, the architects ignored their roles, particularly naive clients, and behaved unilaterally in taking design decisions such as material selection. In addition, they mentioned that a number of design firms escalated the building specifications in order to increase their design fees, as it is a percentage of the building cost. This resulted in specifying luxury materials that does not commensurate with low-income building projects. Furthermore those clients stated that the poor workmanship of construction companies resulted in many construction defects that affected the performance of their buildings. Other clients have a good satisfaction rate of 3.5 out of 5.
2) A number of 14 clients out of 21 refereed that they were not satisfied with the service submitted by maintenance contractors. They rated their satisfaction 1.6 out of 5, where the remaining clients rated their satisfaction with the service submitted by maintenance contractor 2.25 out of 5. Through the interviews conducted with clients, they mentioned that the faults of design and construction cause a number of problems which the maintenance contractor had to solve. This task is being difficult to do because of the poor workmanship of the maintenance contractors and the need to remove and re-construct affected parts. In addition, clients stated that the end users behaviour and habits as well as the increasing number of their children helped damaging many of the building facilities.
3) (3)_About 62.5 % of the end users rated their satisfaction with the service submitted by maintenance contractors at 1.8 out of 5. This could be attributed to the increasing demand for maintenance work due to design and construction faults as well as the damage occurred by end users. One important reason is the poor workmanship of maintenance companies working in the commercial city of Musaffah. This is because of the lower requirements for a company to embark maintenance work which, enabled unqualified companies submit and win tenders at lower cost. The remaining end users had an average satisfaction at a rate of 2.5 out of 5.

7.3 Maintenance Work

Table (4) summarise the results of the questions asked to the maintenance contractors.

Table 4. Summary of Maintenance Contractors Response

Indicator	No. of Maintenance Contractors (out of 3)	Rate (out of 5)
How is it easy to maintain sanitary ware?	3	2.25
How is it easy to maintain aluminium, glass and carpentry works?	3	3.5
How is it easy to maintaining block work, plastering and painting?	3	4.5
How is it easy to maintaining Flooring and external finishing?	3	4.35
How is it easy Maintaining electro-mechanical services?	3	3.75
Remarks:		

Figure 8. Falling of External Marble Cladding

Figure 9. Concealed Sanitary Pipes

Figure 10. Congested Pump Room

Figure 11. Using Service Rooms as Accommodation

8. SUMMARY OF FINDINGS AND CONCLUSION

Having reviewed the concept of assessing building performance in order to improve sustainability for low-income building projects and bearing in mind the previous results derived from the case studies, the research may reach the following conclusions:

1) Government authorities have to engage clients and end users in the briefing and design process. So, their requirements could be adequately captured and reflected in the building design. This will facilitate the achievement of clients and users satisfaction and eliminate further modifications of facilities.
2) Government authorities have to play more effective role to organise the relationship between the client and the designer. In addition, particular attention has to be paid to the development of a list of specifications, which every design firm have to abide with during the design process. Furthermore, it is highly recommended that government authorities and construction professionals adopt Value Management techniques as an effective technique to achieve the project objectives at the most cost effective manner through generating and evaluating creative solutions.
3) Design firms and construction companies should be obliged to use locally made materials to avoid the problem of maintaining imported materials. This will encourage the national industry and hence improve the economy and society.
4) Designers have to consider the whole project life cycle and specify durable material that copes with the environmental climate.
5) Avoid the use of curtain wall in the design of building façade. Such curtain walls do not suite the climate of the United Arab Emirates and similar other gulf countries that have the same climate, which is hot and humid most of the year. This will help reducing the exposure of the building to sunlight and hence, reduce the air conditioning capacity to cool building.

6) Avoid both hiding sewerage pipes and using concealed ducts in order to facilitate rectifying any water leakages. In addition, sanitary pipes have to be exposed or kept in accessible ducts via inspection doors. Furthermore, areas which use water have to be placed away from electric rooms. Furthermore, wet areas have to be placed away from electric rooms.
7) Designers have to pay more attention to delete any items that will not be used in the future. In addition, building regulations have to be revised to modify the dimensions of services rooms and O.T.S to facilitate the maintenance process. Furthermore, furnished plans for service rooms have to be carried out during the design process to make ultimate use of the rooms area.
8) Government authorities have to increase the qualifying level of maintenance companies wishing to submit for maintaining low income residential buildings in order to improve the sustainability of these buildings.

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