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Sustainability Model from Cradle-to-Gate: Residential Buildings in Palestine

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Abstract: Aim of study is to develop a sustainable model for residential building sector in Palestine by tracking the sector from cradle to end of construction process. In the sustainability model, all input resources to the model will be specified and connect to the outputs of the building process involving all dynamic contributors; labor, water, and energy. Based on the sustainability supply chain a model is implemented for a 100 m^2 residential building. For the implemented case study all, necessary costs have been included showing the total cost of this building. The Value Creation Index of the investigated case has been estimated showing the ratio between the revenues gained by the local contracting companies and cost incurred in the building. The large consumed resources indicate the importance and need for creating a sustainability model for the sector.

Keywords: Building construction, sustainability model, value creation index, building emissions, cradle-to-gate

1. Introduction

1.1 Background

Building sector contributes significantly to the GDP and at the same time contributes to the consumption of earth resources and the damage to the environment. Hence, interest in sector sustainability is increasing worldwide and at the same time linking this sector to Sustainability Development Goals (SDG). Building sector can be linked to Sustainable Development Goal (SDG) including Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all, Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation, Goal 11: Make cities inclusive, safe, resilient and sustainable, Goal 12: Ensure sustainable consumption and production patterns, Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.

For the Palestinian national economy, the construction sector is one of the key economic sectors. Therefore, the construction sector has occupied the foremost position among the rest of sectors, mainly in the creation of new jobs (Raymond, 2000, Pearce and Vanegas, 2002). This is a considerable proportion covered by this sector. Construction industry is one of the most effective sectors of the labors force in Palestinian urban and rural. Currently, construction sector employs about 10.8% of laborers in a direct and 30% in an indirect way (Osaily, 2010).

Figure 1 shows the contribution of the construction sector in the value added to the Palestinian economy during 2018. Figure 2 depicts the added value and output of the sector over the years 2000-2018, with an increasing trend. In figure 3 the growth of sector is presented as number of annual issued licenses, built area, and number of working force involved.

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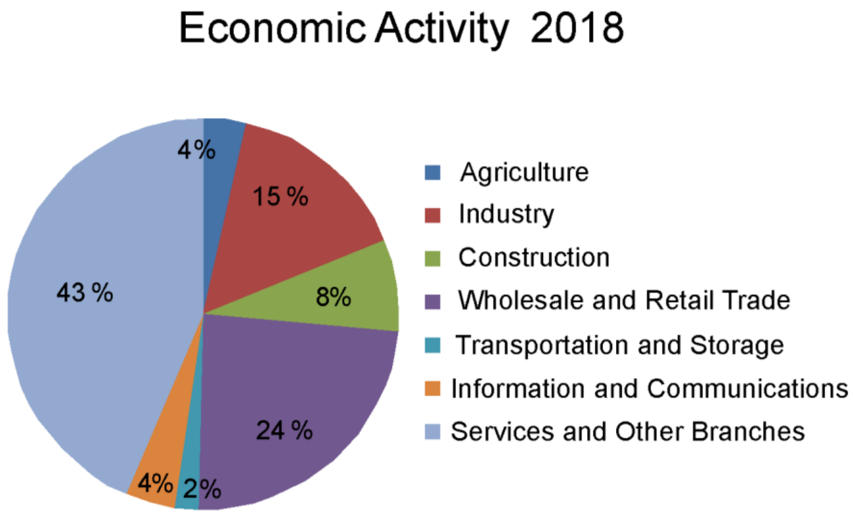

Fig. 1 - Added value by economic sectors to Palestinian economy during 2018 (PCBS, 2019)

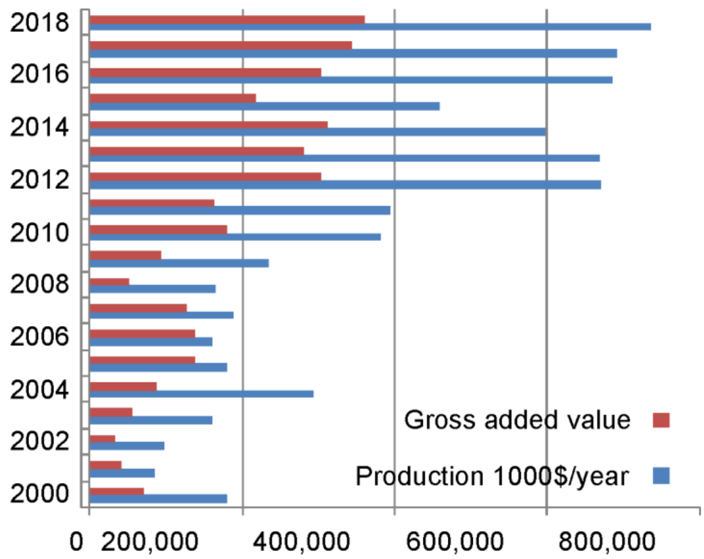

Fig. 2 - Added value and output of construction sector 2000-2018 (PCBS, 2019)

Through a complementary process, several parties contribute to the construction sector, such stakeholders are private and public sectors, international donor countries, universities, institutes of international financing institutions, and banking sectors. Stakeholders make available necessary services, fund construction projects, provide necessary materials, and organize the construction contracting profession (Pearce and Vanegas, 2002, Menzies and Banfill, 2007, The Islamic University Journal, 2008). According to sustainability report for Palestine 2018 the building sector is contributing to the goal 8 with "Support affordable, safe housing". Among the Challenges to achieve the SDG, the 2018 report said "Adequate, safe and affordable housing remains a key challenge, particularly in the areas where the government has difficulty accessing". In East Jerusalem, there is a chronic shortage of more than 10,000 housing units. In Gaza, a shortage of 70,000 housing units and a need for 13,000 extra houses per year to account for the rapidly growing population." (Sustainable Development, 2018).

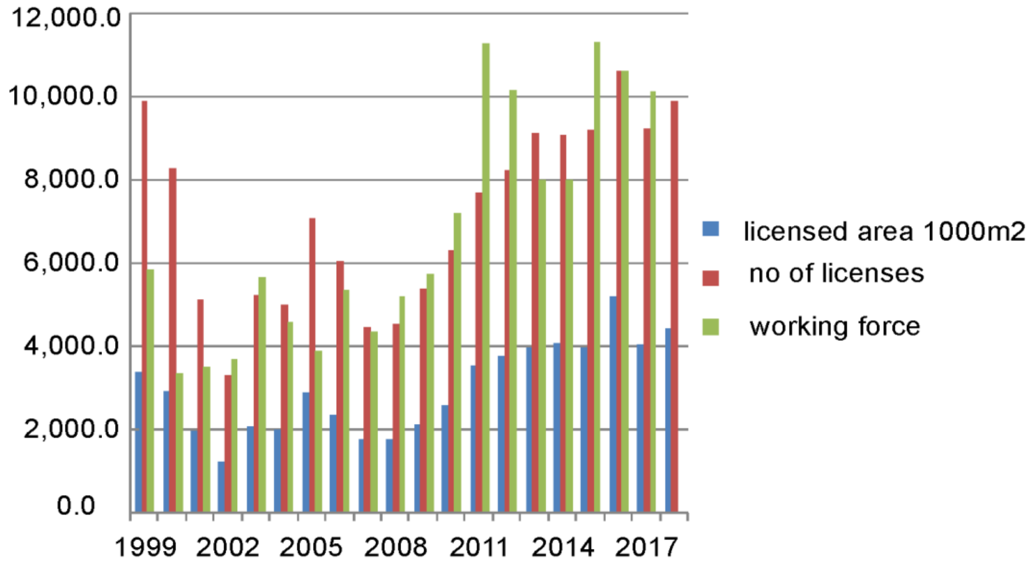

Fig. 3 - Working force, number of issued licenses and licensed area per year 1999-2018

Due to the current political situation in Palestine control of natural resources, including water and energy is impossible and complicated. As a result of this reality, the lack of exploitation of energy resources in Palestine, despite indicators of availability, inevitably increases the operating cost of buildings, and the depletion of its limited energy resource. The import of petroleum products is not authorized by Palestinian Authority, and therefore all the products of petroleum and electric power come through borders that are not controlled by Palestinians as well. Energy indicators show that energy prices are among the highest in the region and the consumption is relatively lower than other countries in the region (The World Bank, 2016). Similarly, water prices are high and availability of water is very low as shown in table 1.

Table 1 - Energy and water indicators for Palestine

Indicator	Value	Reference
Electricity prices, ($/kWh)	0.17	(World Data, 2019)
Annual Electricity Consumption Per Capita (KWh/Capita)	1093	(World Data, 2019)
Per capita energy consumption, (GJ)	11.511	(World Bank, 2016)
Energy Dependency Rate (%)	86.4	
Renewable energy share in the total final energy consumption (%)	11.7	
Water prices, ($/m^3)	0.7-1.5	(Water sector regulator council, 2016)
Daily Per capita water consumption, (liter/capita/day)	88.3	(PCBS, 2019)
Water dependency, (%)	22	(PCBS, 2019)

1.2 Literature Review

In assessing building construction on the environment (Raymond, 2000) discussed the various stages of building construction and their effect on the environment. He divided building life into; Initial works -site preparation, transportation, construction, maintenance and repair, major refurbishment, and building decommissioning. The effect on environment and human health is discussed during each stage of the building construction including energy consumption, noise, and material consumption. Authors estimated embedded and construction energy as 7-10% of total energy during lifetime and concluded that construction issues are poorly defined in terms of their significance and the range of criteria appropriate for inclusion in the assessment.

Pearce and Vanegas (2002) developed a comprehensive definition for sustainability in the built environment using system concept for the construction facilities and the earth system.

Menzies and Banfill (2007) provided a review of life cycle assessment and embodies energy databases for buildings construction, and presented a case of steel as building material he concluded that a factor of six is found as difference in the various databases embodied energy and that comparison is very difficult without further analysis.

Khasreen et al. (2009) discussed LCA applications in the building sector, by reviewing a number of life-cycle studies applied to buildings and material in Europe and the United States. They found a lack of an internationally comparable and agreed data inventory and assessment methodology.

Abolore (2012) investigated the environmental sustainability of building construction in both Nigeria and Malaysia, he concluded that in both countries sustainability is not taken into account in the construction industry, such that construction works is impacting negatively the built environment, and that immediate corrective actions are needed.

Robertson et al. (2012) compared the effect of alternative designs of typical North American mid- rise buildings on cradle- to- gate LCA assessment. They found out that the laminated timber building design offered a lower environmental impact over the concrete designs in ten of the eleven assessment categories.

Yüksek (2015) investigated the energy consumption at various stages of building life cycle for Turkey, to conclude that the selection of building material and its energy features are important parameters to provide an efficient energy building.

Castro et al. (2015) studied the difference between the various building sustainability assessments BSA as applied to health care buildings HBSA. They believe that current BSA should evolve to accommodate a number of criteria they presented in their paper.

In their paper Moschetti et al. (2015) presented a methodology to set a reference value for building environmental impact, energy outputs and global costs. For this aim they analyzed four residential buildings categories in Italy and using LCA through SimPro software. They found that Italian residential buildings over life cycle consumes annually 140kWh/m^2 of energy and produce 35 kg CO2 eq./m^2.year leading to a global cost of 1420 Euro/m^2.

Marjaba et al. (2016) reviewed matrices for sustainability and found LCA is the state of art that can quantify environment sustainability, however still faces many challenges. On the other hand, LEED, BREEAM, and DGNB building certification systems do not address all sustainability requirements.

Castro et al. (2017) explained a proposal for healthcare building sustainability assessment method for Portugal, which included the structure and system of weights of the sustainability criteria which they called HBSAtool-PT.

Sharma (2018) have developed a green building sustainability empirical relation model through a questionnaire. They showed that a collaborative effort is required from government and stakeholders to come up with a strategic –mix that can lead to sustainable development. According to the authors the developed generic model can be applied to commercial and residential green buildings.

Zavadskas et al. (2018) presenting a special issue of sustainability where27 papers converging construction technology and materials, economic analysis, infrastructure and sustainable architecture. By employing variety of tools including multi-criteria decision- making they found that MCDM is suitable to assess sustainability in buildings.

Carvalho et al. (2019) discussed using Building Information Modelling BIM to optimize the building sustainability assessment methods. They concluded that using BIM in construction industry is an essential path to optimize the building performance and reduce it environmental impacts.

Said and Alsamamra (2019) presented an overview of green building potential in Palestine and carried out a SWAT analysis concluding good government and engineers' association interest, availability of clean energy resources, however laws and regulations are absence, as well as lack of experience and training.

Apanavičienė et al. (2020) investigated the impact of construction stages on the building sustainability assessment rating systems, where he considered LEED, BREEAM for seven buildings in Lithuania. They considered five criteria; project management, responsible purchase of building materials, use of legal timber materials, construction waste and the protection against environmental contamination. They concluded that findings could serve as a framework for contractor's organizations.

Katerusha (2021) in a study covering Swiss and German architecture, civil, and environmental engineering curricula found that sustainability contents are well covered in Switzerland while in Germany there is a need to increase theoretical and practical coverage of sustainability contents.

Yanlin (2021) analyzed the sustainability of the construction industry in China for the period 2012-2018 with regard to efficiency indicators related to construction industry. He concluded that there is no sustainable development in the construction industry due to lack of investment in green technologies.

Sustainability of building is of interest to many stakeholders and beneficiaries hence different criteria are set to quantify the sustainability and various rating and certification systems are developed for this purpose, such included the LEED, and BREAM. Some only cover the building phase, while others extend to raw material, and to the operation and demolishing phases. There is an immense amount of international literature dealing with sustainability in building construction covering wide range of assessment tools and methods and list of indicators. However, there is very little published work on the sustainability of buildings and construction sector in Palestine. This paper develops a qualitative model of building sustainability, and then implements it using a case study of typical residential building in Palestine. The system boundary is limited to the cradle- to-gate system boundary.

2. Cradle-To-Gate Sustainability Model

2.1 General Sustainability Model

In the past people used to build their houses out of mud or clay and hay reinforced by stones. The walls used to be around 100 cm thick and the roof is made by crossing four arcs in the shape of a dome or hemisphere. In some world regions, where there is a danger of earthquakes or volcanoes, people used to build their houses out of wood, where the walls are made of flat wooden plates and the roof is made like a triangular hood. These types of building shapes prevent from having multi flats and restrict the building to one or two floors.

After discovering the concrete, building construction became much easier and stronger. Concrete reinforced by steel bars enabled people to construct Cartesian rectangular buildings which help to have several floors that reached to hundreds of floors in the case of high-rise buildings and sky scrapers. The modern Palestinian building construction sector adopted concrete reinforced by steel bars for both commercial and residential buildings. Palestine has a rocky mountain landscape full of natural rocks and stones with high characteristics adequate to building requirements, therefore, stones are widely used in decorating the outer surface of the buildings and even in the tile and inner decoration (Abu Hanieh et al., 2014).

In this research, the Integrated Definition (IDEF) modelling technique is used to represent the building construction process in Palestine. Figure 4 shows the building construction model where the inputs of the process in general can be summarized as follows:

i. ***Overground resources:*** the building resources that are found on the ground without mining and these resources exist widely in Palestine. Stone, sand and clay are considered the three main components out of which most of the construction materials are formed.
ii. ***Underground resources:*** metals like iron, copper and aluminum are underground resources; these resources can be obtained through mining processes. These metals do not exist in Palestine; thus they are mostly imported from outside the country or recycled from local metallic wastes.
iii. ***Synthetic resources:*** Synthetic materials like glass, polymers and plastics are mostly imported or recycled to be used in the construction process.
iv. ***Forestry resources:*** mainly wood, is used widely in the building construction procedures. Palestine does not have much trees or forests to be exploited for wood extraction hence this material is imported from outside the country.

Human resource in the form of skilled, unskilled workers and engineers exists strongly in Palestine. Working in construction is considered as one of the major job markets, and make a good contribution to the Palestinian GDP. Water is involved in the different construction processes either during the preparation of the main input materials or during the construction processes itself. Energy is involved as well in different forms where conventional energy is used as petroleum products for transportation and in the form of electric energy in concrete mixing plants and metal working shops.

During the building construction process, three main outputs emerge out. The first output is solid waste coming out of the process where contractors face a problem of getting rid of this waste. The second output is the emissions, these emissions come from the concrete mixing plants, transportation techniques and dust coming out of the construction sites. The third output is the health and safety for the works and the necessity to follow the international standards which does not exist in many construction sites.

2.2 Inputs of the Sustainability Model

Figure 5 depicts a detailed explanation of the underground resources mentioned before. Iron, copper and aluminum are the three main metals used in construction process. Iron is used to produce construction steel bars used to reinforce the concrete slabs in order to increase the strength and work with wider spans between columns. External doors and windows are usually made out of steel profiles and sheets because it is stronger than other materials. Copper is usually used to manufacture the electric wires for the electric network because copper has a better electrical conductivity. Aluminum is mainly used to manufacture the profiles of windows and doors. Water and energy are involved in most of the previous metal extraction and manufacturing processes as well as during the construction process.

The over-ground resources are shown in figure 6. Stone, sand, and clay are found over-ground in Palestine in large quantities and are extracted by quarrying. Stone and marble used for external and internal construction are formed by cutting the cubic stone block into slices adequate for decorating the building in specific shapes. When these stones are crushed into small pieces they are transferred to aggregate that can be used either for roads or concrete; when stone is grinded and mixed with clay it can be transferred to cement in special ovens and processes. Ready-mixed concrete is done by mixing cement with aggregate and sand that can be found either on the sea coast or in desert areas. Energy and water are required in the different processes of these resources.

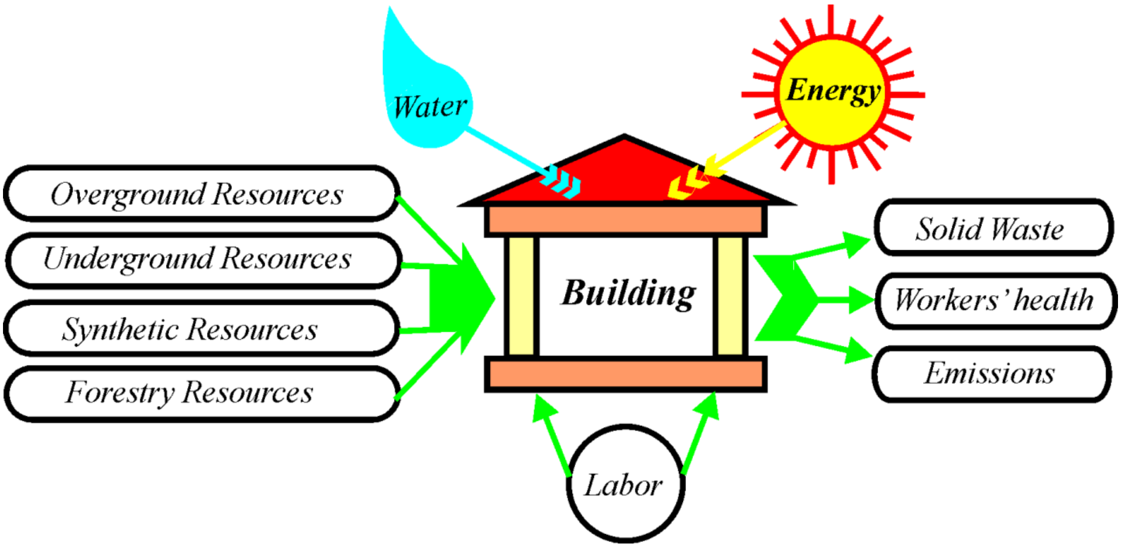

Fig. 4 - General model of a residential building process showing inputs and outputs

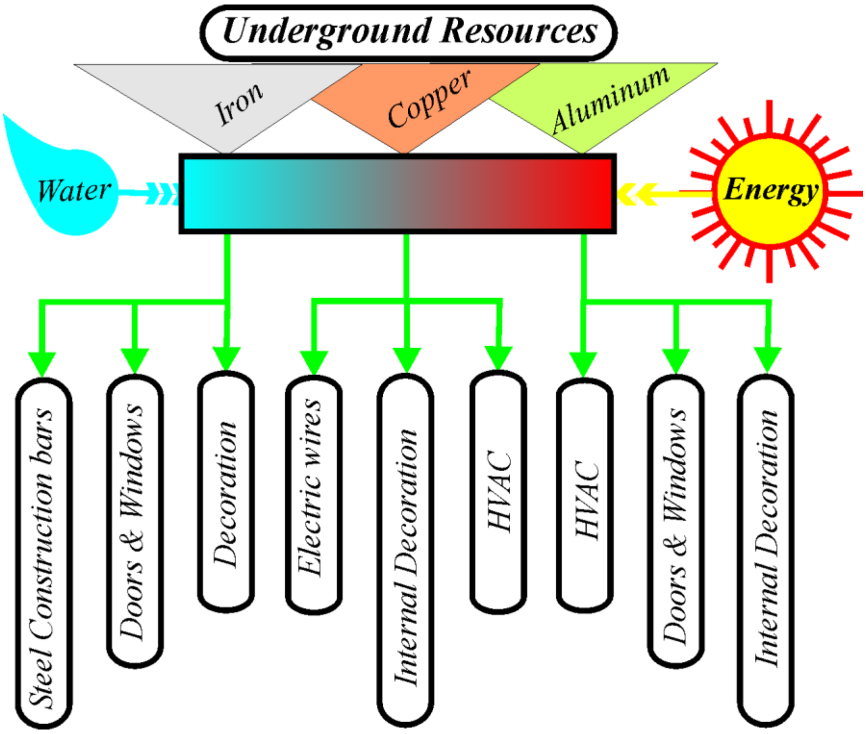

Fig. 5 - Underground metals construction resources and their applications

Synthetic resources are detailed in figure 7; solid polymers represent the plastic materials used in the fabrication of some household appliances as well as in the different equipment used in electric network and electric wire coating. Solid polymers like PVC plastic are used to manufacture the sewage and water plastic pipes and fittings while liquid polymers are used to produce paintings and insulation materials. Polystyrene, polyurethane foam and rock wool are used as thermal insulation materials for walls and different HVAC air conditioning and heating thermal applications. Glass is another synthetic material used to cover doors and windows and solar collectors forming a transparent cover that allows sun rays and heat to penetrate through and prevents air and surrounding dust from coming in.

Wood as a forestry resource is not widely used in building as a construction material in Palestine but still it is used in some applications like internal doors and windows, garden appliances, internal decoration and different building carpentry as shown in figure 8. Water and energy are involved in the fabrication processes related to wood industries as well as during the construction process.

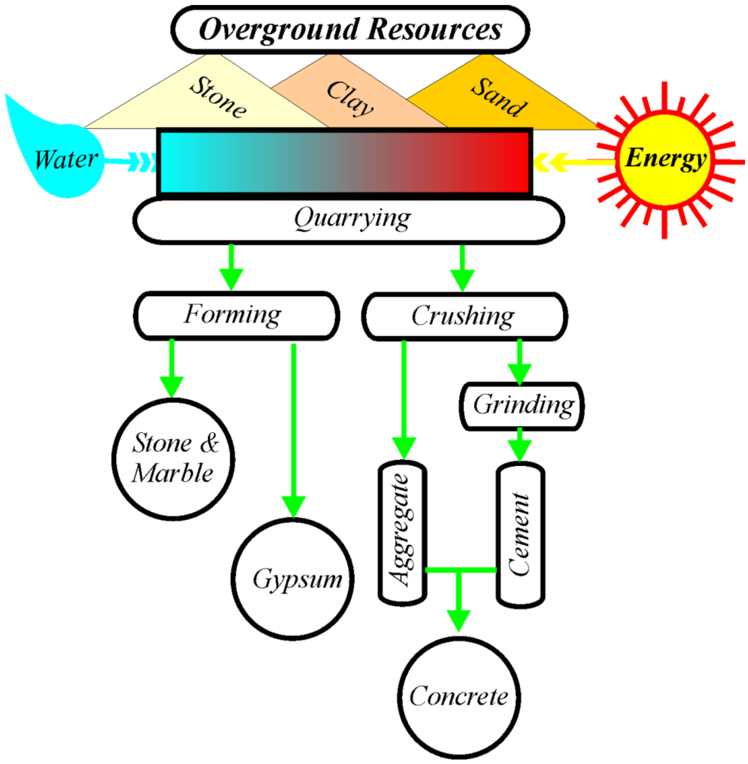

Fig. 6 - Over-ground resources for construction and applications

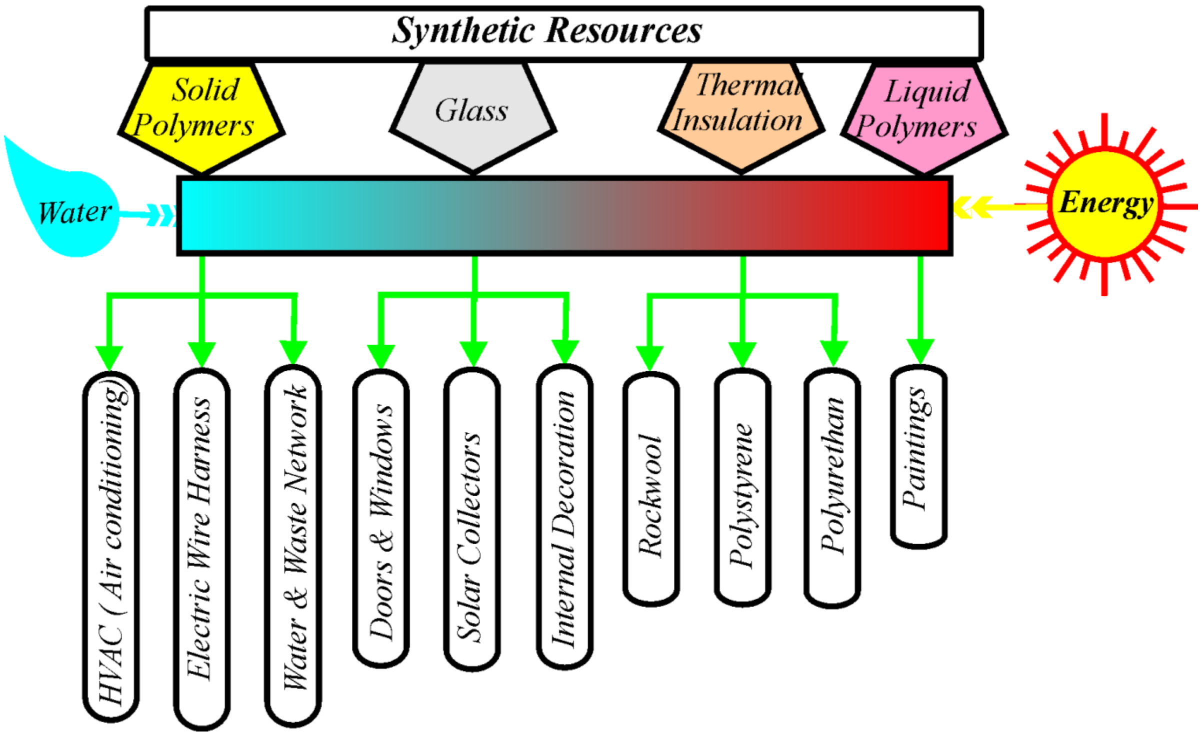

Fig. 7 - Synthetic resources and applications

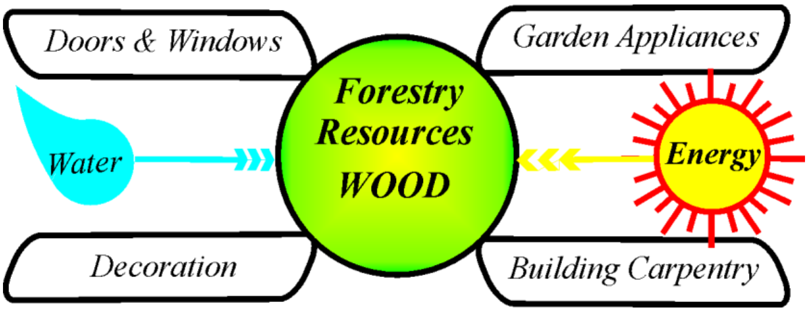

Fig. 8 - Forestry resources and applications

2.3 Outputs of the Sustainability Model

The building itself is the main desirable output of the construction process but this output is accompanied with other undesirable outputs that harm people and the environment or problems to be solved. The first undesirable output is the solid waste depicted in Figure 9 which is divided into five types of waste; concrete waste that is produced during construction or from demolishing or repairing building sites is usually solved by reclaiming it to fill into excavated cavities and low-level places. In Gaza strip many projects were experimented to recycle the concrete waste of demolished houses by crushing and re-mixing it again with cement to be reused in new buildings (Abultayef et al., 2018). The waste of stones comes in the shape of smaller size broken stones and this can be reused again after resizing it to new sizes and shapes. Otherwise, if the stone pieces are not reusable they can be fed into stone crusher and turned to aggregate to be used in concrete mixture (Abu Hanieh et al., 2014). Packaging cartoons and plastics are usually recycled and transported to the factories to be used in manufacturing. Metal waste either steel, copper or aluminum made a new job opportunity for many people who work in collecting this metallic waste pressing it and transferring it to the foundries where it is casted again to new shapes and manufactured pieces.

The second undesirable output from building construction is the emissions, detailed in Figure 10. The first source of these emissions is the sound pollution coming out of the running engines and moving vehicles. A recent study has been published by (Abu Hanieh and Al Balasie, 2021) about the influence of noise and vibrations in the stone cutting factories which explains the high environmental influence of noise pollution. Noise pollution can be solved either using silenced equipment, noise barriers or using protection headsets for workers. The second source is the dust generated in the building sites and concrete mixing plants. Keeping in mind that Palestine has a dry environment most of the year which makes the atmosphere completely dusty around the building work places and near the quarries, stone cutting factories and concrete plants. Dust problem can be solved by cleaning moving vehicles and trucks, watering surfaces or asphalting roads which is a very expensive solution.

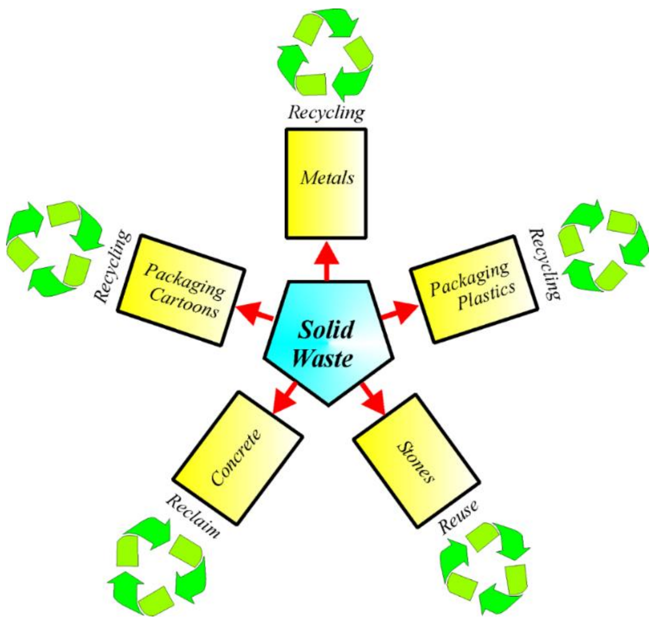

Fig. 9 - Solid wastes out of the construction process and their remedial processes

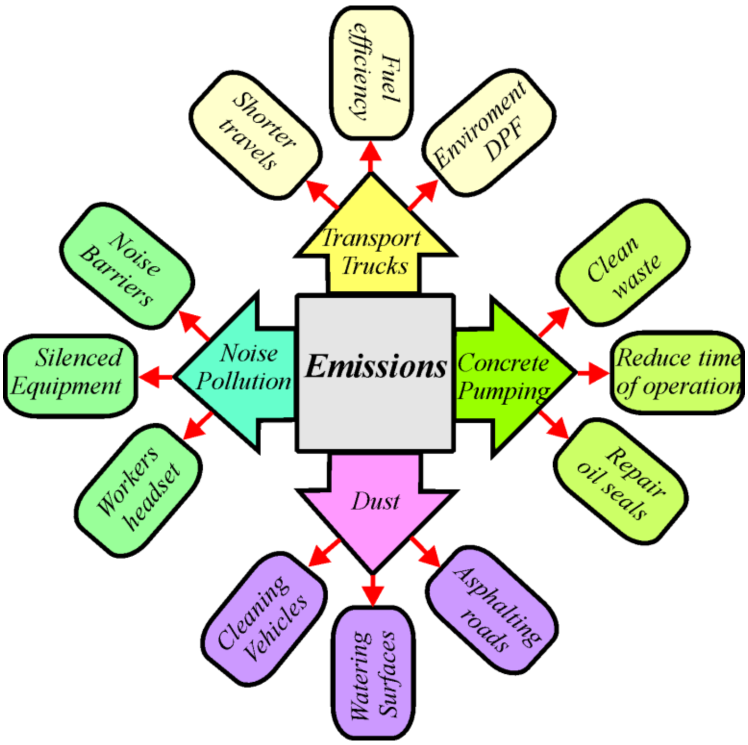

Fig. 10 - Sources of emissions in the construction sector

Transporting raw materials used in construction like cement, aggregate, sand and all other materials are usually done on road by trucks; these trucks use diesel engines that produce large quantities of soot and NO_x emissions into the environment. This problem can be overcome by selecting the shortest tracks and travels for the moving trucks besides to using fuel efficient vehicles and modern vehicles with Diesel Particulate Filters (DPF). Ready-mixed concrete transportation and pumping is another source of emissions. Sometimes concrete spelled out on the roads during transportation due to defect in the concrete pump. This can be cleaned and reused after reparation; another way to reduce pollution from concrete pumps is by reducing the operation time of the engine through stopping the engine during the waiting time between mixers. Concrete pumps involve sophisticated hydraulic systems that start to leak hydraulic oil after a specific operating time, these fittings and seals should be repaired continuously to avoid pollution caused by this leakage.

The last undesirable output of the building construction work in Palestine is health effects and injuries resulting from the lack of occupational safety measures of the workers in the sector. Figure 11 shows the six needs for occupational safety in building sector. The first need is to protect the lungs and respiratory system of the worker from dust using face masks. The second need is to protect the worker's eyes from dust and welding rays using goggles. The third need is to protect the worker's feet from dust and harm by wearing protecting shoes. The fourth need is to protect the worker's ears from noise and sound pollution using ear protection headset. The fifth need is to protect the worker's hands from dirt and irritation by chemicals using safety gloves and the last need is to protect the worker's head from any harm or shock using special protecting helmet.

2.4 Implementation on Real Building

To implement the foregoing sustainability model, a 100 m^2 residential building has been studied where the detailed costs of this building are presented in Figure 12. It is clear that the contributions of the cement, sand and aggregate are small since they are used as separate materials only for coating and tile installation. However, they are also involved in the ready-mixed concrete.

More details are shown in table 2 about the cost items and percentages. Major cost items are ready-mixed concrete, steel bars, contracting, stone, and bricks. Energy forms around 7% of the construction cost. The land cost is excluded from building cost as it varies from location to another.

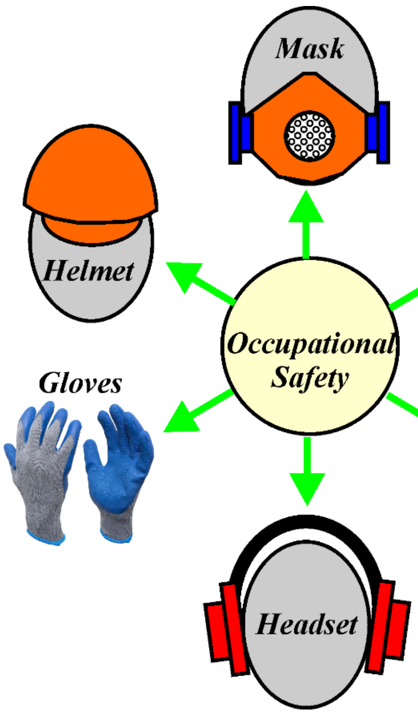

Fig. 11 - Types of occupational safety needs in building construction

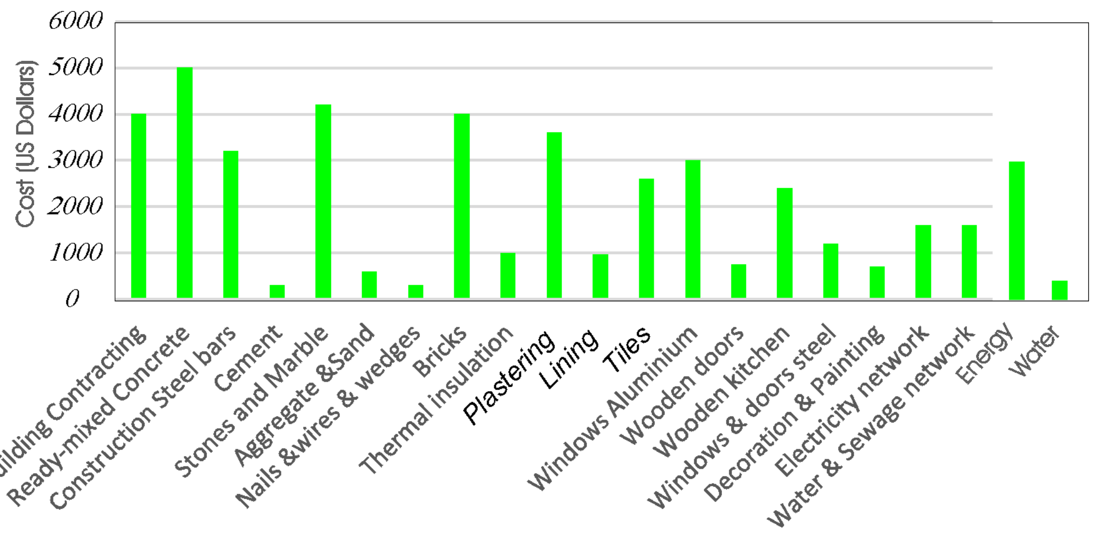

Fig. 12 - Costs of constructing a 100 m^2 residential building

Table 2 - Costs of constructing a 100 m^2 residential building

Material	Quantity	Unit	Unit cost ($)	Cost ($)	Percentage (%)
Building Contracting	100	m^2	40	4000	9.75
Ready-mixed Concrete	50	m^3	100	5000	12.19
Construction Steel bars	4	ton	800	3200	7.80
Cement	3	ton	100	300	0.73
Stones and Marble	120	m^2	35	4200	10.24
Aggregate &Sand	50	Ton	12	600	1.46
Nails &wires & wedges	30	Box	10	300	0.73

Bricks	4000	brick	1	4000	9.75
Thermal insulation	100	m^2	10	1000	2.44
Plastering	360	m^2	10	3600	8.78
Lining	120	m^2	8	960	2.34
Tiles	130	m^2	20	2600	6.34
Windows Aluminum	15	m^2	200	3000	7.32
Wooden doors	5	door	150	750	1.83
Wooden kitchen	12	m^2	200	2400	2.93
Windows & doors steel	15	m^2	80	1200	2.93
Decoration & Painting	700	m	1	700	1.71
Electricity network	40	point	40	1600	3.90
Water & Sewage network	16	point	100	1600	3.90
Energy	17647	KWh	0.17	3000	7.32
Water	211	m^3	1.5	310	0.77
Building cost (BC)				**$ 44320**	

Figure 13 shows a simple calculation of the different resources used in the 100 m^2 building where the over-ground resources have the highest percentage followed by the underground resources. The labor here is represented by the contracting costs which is quite significant. This explores the need to have technically qualified skilled labor in this sector. The energy considered here is that consumed during construction and does not include the embedded energy, however it still a significant cost. Hence using renewable energy resources whenever possible can reduce impact on the environment.

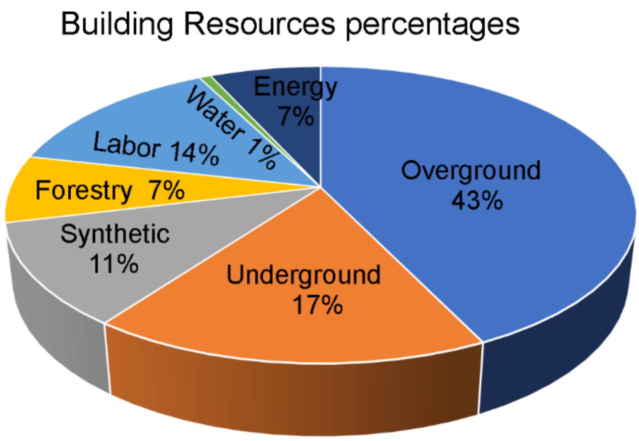

Fig. 13 - Percentages of the contribution of different resources in building

2.5 Value Creation Index

The Value Creation Index (VCI) gives an indication about the profits gained by contracting companies and individuals working in the field of residential building construction. VCI is the ratio between revenues and costs taking values from table 3;

$$VCI = \frac{Revenue}{Cost} \quad (1)$$

Data about these revenues and costs of apartment building in Palestine have been gathered from local contractors in the different Palestinian cities and are reflected in Table 3. The cost of building here is calculated by:

$$Cost = BC + 50 \times LC \quad (2)$$

Where,
Cost = is the total cost of a 100 m^2 apartment in residential building
BC = Building cost of a 100 m^2 apartment residential building taken from Table 2
LC = Land cost taken from Table 3 as $/$m^2$

Considering that a 1000 m^2 piece of land can be used to build 20 apartments in five floors which is the typical way of residential building in Palestine, hence the share of each apartment from the land is 50m^2.

Table 3 - Costs, revenues and Value Creation Index (VCI) of 100 m^2 apartments in Palestine

City/place	Land, $/$m^2$	Cost	Revenue	VCI
Jerusalem city	2000	144326	300000	2.079
Jerusalem suberbs	300	59326	100000	1.686
Ramallah north-west	1500	119326	160000	1.341
Ramallah south-east	300	59326	100000	1.686
Ramallah suberbs	80	48326	70000	1.448
Birzeit	200	54326	70000	1.289
Nablus city	1000	94326	130000	1.378
Nablus suberbs	200	54326	70000	1.289
Bethlehem city	300	59326	100000	1.686
Bethlehem suberbs	100	49326	70000	1.419
Hebron city	400	64326	80000	1.244
Hebron suberbs	120	50326	60000	1.192
Tulkarem city	350	61826	70000	1.132
Tulkarem suberbs	70	47826	50000	1.045
Jenin city	200	54326	70000	1.289
Jenin suberbs	40	46326	50000	1.079

Based on these data, Costs and Revenues are represented in Figure 14 which shows that Jerusalem has the highest cost and the highest revenue. This increase is caused mainly by the high cost of the land. Jerusalem is followed by Ramallah and then Nablus in high prices while in the rest of Palestinian cities prices are similar.

VCI is calculated and depicted in Figure 15; this figure shows that index is quite high in Jerusalem more than 2 followed by Ramallah, and Bethlehem around 1.6 while it ranges for the other cities from 1.1 to 1.5.

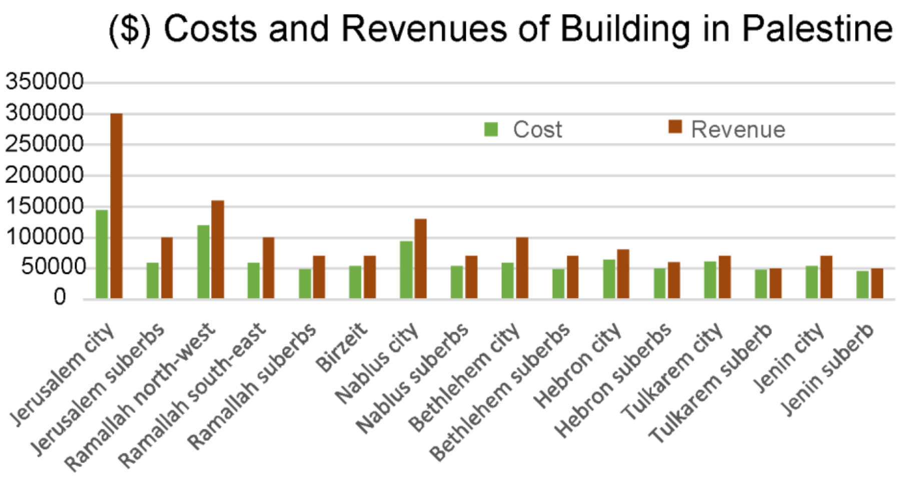

Fig. 14 - Costs and revenues of apartments in Palestine

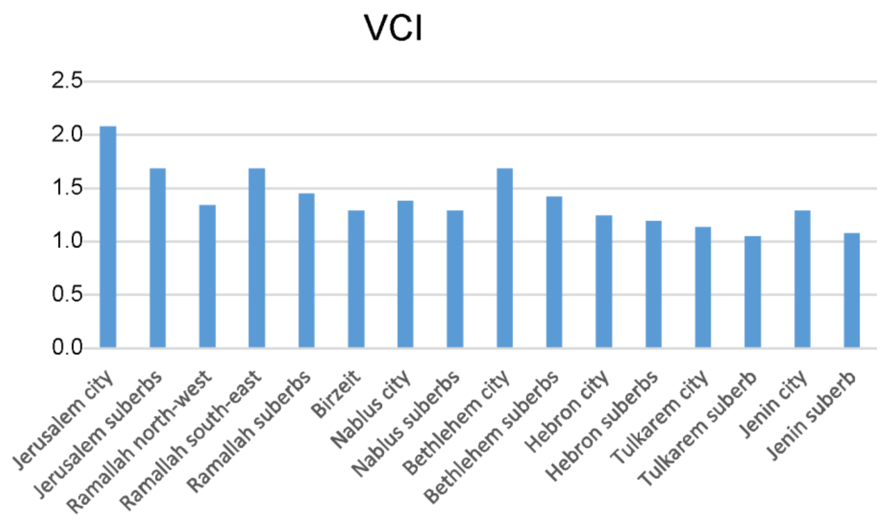

Fig. 15 - Value creation index of commercial apartment trade in Palestine

5. Conclusions

The foregoing study concentrated on handling the cradle to gate lifecycle of the residential building construction in Palestine in order to achieve a sustainable model for this important sector in Palestine. A brief background, literature review, and some statistics have been collected from local sources to give an indication about the recent situation of the sector. In order to build a complete model, the inputs and outputs have been arranged in sequential block connected to each other through the process itself and showing the other contributing factors like water, energy, and labor. Each input and output has been detailed in a separate flow diagram showing all required resources for each factor. A case study of 100 m^2 residential building has been taken as a sample to make a good estimation, and then it can be scaled up for larger areas. The costs and revenues of building construction have been calculated in order to compute the value creation index for most of the Palestinian governorates. Some suggestions to turn this sector into a sustainable one are discussed. These included minimizing waste, conserving water and energy, reuse, and recycling materials. Reducing the impact on workers' health and safety is discussed as well. Further involvement of social and environmental impact of the economic situation of this sector can be included in further work. The sector presents a good opportunity for generating profits as indicated by VCI, however, it consumes larger precious land, stone, and water resources as well as consumes larger quantities of the imported steel, wood, glass, and plastic materials. The current situation of the sector is unsustainable and more concern of its sustainability needs to be addressed by sector stakeholders.

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References

Abu Hanieh, A., AbdElall, S. and Hasan A., (2014). Sustainable Development of Stone and Marble Sector in Palestine, Journal of Cleaner Production (JCLEPRO), Elsevier, 84: 581 – 588.

Abu Hanieh, A. and Al Balasie, A., (2021). Noise and Vibrations Reduction of Stone Cutting Factories, International Journal of Mechanical and Mechatronics Engineering, IJENS, 21(1): 48-63.

Abualtayef, M., Ziara, H., Seif, A. K. and Masria, A., (2018). Possibility of Land Reclamation using Construction Waste in Gaza Strip, International Research Journal of Engineering and Technology (IRJET), 05(07).

Abolore, A. A., (2012). Comparative Study of Environmental Sustainability in Building Construction in Nigeria and Malaysia. Journal of Emerging Trends in Economics and Management Sciences (JETEMS) 3(6): 951-961.

Apanavičienė, R., Maliejus, K. and Fokaides, P., (2020). Sustainability Assessment of the Building Construction Stage Using Building Sustainability Assessment Schemes (BSAS) IOP Conf. Series: Earth and Environmental Science 410, 012064 IOP Publishing doi:10.1088/1755-1315/410/1/012064.

Castro, M. de F., Mateus, R. and Braganc, L., (2015). A critical analysis of building sustainability assessment methods for healthcare buildings¸ Springer Science + Business Media Dordrecht 2014 Environ Dev Sustain. DOI 10.1007/s10668-014-9611-0.

Castro, M. de F., Mateus, R. and Bragança, L., (2017). Development of a healthcare building sustainability assessment method Proposed structure and system of weights for the Portuguese context. Journal of Cleaner Production, 148: 555-570.

Carvalho, J.P., Bragança, L. and Mateus, R., (2019). Optimizing building sustainability assessme nt using BIM. Automation in Construction 102: 170–182.

International Bank for Reconstruction and Development/ The World Bank, (2016). WEST BANK & GAZA ENERGY EFFICIENCY ACTION PLAN 2020-2030, Final Report June 2016.

Katerusha, D., (2021). Attitude towards sustainability, study contents and the use of recycled concrete in building construction - case study Germany and Switzerland. Journal of Cleaner Production, 289, 125688.

Khasreen, M. M., Banfill, P. F.G., and Menzies, G. F., (2009). Review Life-Cycle Assessment and the Environmental Impact of Buildings: A Review. Sustainability 2009, 1: 674-701; doi:10.3390/su1030674.

Marjaba, G.E. and Chidiac, S.E., (2016). Sustainability and resiliency metrics for buildings – Critical review
Elsevier. Building and Environment, 101(15): 116-125.

Menzies, G. F., Turan, S. and Banfill, P. F. G., (2007). Life-cycle assessment and embodied energy: a review
Proceedings of the Institution of Civil Engineers -Construction Materials ISSN 1747-650X | E-ISSN 1747-6518, 160(4): 135-143.

Moschetti, R., Mazzarella, L. and Nord, N., (2015). An overall methodology to define reference values for building sustainability parameters. Energy and Buildings, – Elsevier.

Osaily, N. Z., (2010). The key Barriers to Implementing Sustainable Construction in West Bank – Palestine. Master Thesis in University of Wales.

Pearce, A. R. and Vanegas, J. A., (2002). Defining Sustainability for Built Environment Systems: An Operational Framework. International Journal of Environmental Technology and Management. 2: 94–113 https://doi.org/10.1504/IJETM.2002.000780.

PCBS, (2012). http://www.pcbs.gov.ps/PCBS_2012/Publications.aspx?CatId=47, retrieved March 5, 2021.

PCBS, (2018). http://www.pcbs.gov.ps/Portals/_Rainbow/Documents/e_series_BLic_2018q4.html, retrieved March 5, 2021.

PCBS, (2019). http://www.pcbs.gov.ps/portals/_pcbs/PressRelease/Press_En_21-3-2019-water-en.pdf, retrieved March 5, 2021.

Raymond, J. C., (2000). Building environmental assessment methods: assessing construction practices. Construction Management and Economics 18:949–957.

Robertson, A. B., Lam, F. C. F. and Raymond, J. C., (2012). A Comparative Cradle-to-Gate Life Cycle Assessment of Mid-Rise Office Building Construction Alternatives: Laminated Timber or Reinforced Concrete. Buildings 2012, 2: 245-270; doi:10.3390/buildings2030245.

Said, N. and Alsamamra, H., (2019). An Overview of Green Buildings Potential in Palestine, International Journal of Sustainable and Green Energy 2019; 8(2): 20-33, doi: 10.11648/j.ijrse.20190802.11. ISSN: 2575-2189 (Print); ISSN: 2575-1549 (Online).

Sharma, M., (2018). Development of a 'Green building sustainability model' for Green buildings in India. Journal of Cleaner Production. 190: 538-551.

Sustainable Development, (2018). https://sustainabledevelopment.un.org/content/documents/20024VNR2018PalestineNEWYORK.pdf, retrieved March 5, 2021.

The Islamic University Journal, (2008). Series of Natural Studies and Engineering, 16(1): 95-123, ISSN 1726-6807, http://www.iugaza.edu.ps/ara/research/.

Yanlin, L., (2021). Study on the new concept of green building under the sustainable environment and technology International Journal of Environmental Technology and Management. 23(2-4). DOI: 10.1504/IJETM.2020.112968.

Yüksek, Í., (2015). The Evaluation of Building Materials in Terms of Energy Efficiency, Periodica Polytechnica Civil Engineering, 59(1): 45–58, DOI: 10.3311/PPci.7050.

Water sector regulator council, (2016). Performance Monitoring of Water Service Providers in Palestine for the Year 2014. https://www.wsrc.ps/cached_uploads/download/2014-performance-monitoring-report-english-final-1487078258.pd. retrieved March 5, 2021.

World Bank, (2016). http://documents1.worldbank.org/curated/en/851371475046203328/pdf/ACS19044-REPLACEMENT-PUBLIC-FINAL-REPORT-P147961-WBGaza-Energy-Efficiency-Action-Plan.pdf, retrieved March 5, 2021.

World Data, (2019). https://www.worlddata.info/asia/palestine/energy-consumption.php#:~:text=of%20electric%20energy%20per%20year,itself%20with%20self%2Dproduced%20energy, retrieved March 5, 2021.

Zavadskas, E. K., Šaparauskas, J. and Antucheviciene, J., (2018). Sustainability in Construction Engineering. Sustainability 2018, 10, 2236; doi:10.3390/su10072236, www.mdpi.com/journal/sustainability.