Mathematical Model for the Inclusion of Livability Items in Conceptual General Arrangement Design of Long Term Habitable of Mega Floats

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ABSTRACT

Mega-floats are designed for offshore exploration and as floating cities for human habitation. Therefore, livability items are one of the most important design factors such as recreation area, environment system, safety and etc. Many design concepts have been proposed, but the inclusion of livability – related components is not well explained. Livability criteria have not been defined. Basic descriptions and design specifications have not been provided either. The paper proposes an approach for systematic incorporation of livability items into mega-float design concepts. Based on a selected set of livability criteria a list of livability items for the mega-float has been drawn. Area requirement for each livability items has been systematically estimated based on a set of benchmark values. Gross and individual area requirement for livability item on each of the mega-float modules could be estimated. Generic expressions have been proposed and could be applied for non- modular type mega-float design concepts.

KEY WORDS: *Liveability;Megafloat; Concept Design*.

1.0 INTRODUCTION

Megafloats are concepts more advanced than current offshore structures. Megafloats suitable for long term human habitation are intended to be self –sufficient in all aspect including supply of energy and resources for their inhabitants and governance. Advanced megafloats are still at conceptual design stage. Several ideas have been proposed with various concept on floatation, distribution of functional spaces, elements on living conditions and primary facilities.

As highlighted by Zamani at el. [1], Darren [2] describes the Lilypad floating city which has three marinas and three mountains which surround a centrally submerged artificial lagoon below the water line. The function of three mountains and marinas divided as work, shopping and entertainment for the comfortable social environment of city population. The whole set of mountains planted with a suspended garden for producing their own food through and aquaculture farming technique. A centrally submerged artificial lagoon collects rainwater and purifies the rain water further also act as ballast of the city. Vincent [3] describes the application of renewable energy as power generation, such as solar, thermal and photovoltaic energies, wind energy, hydraulic, tidal power station, osmotic energies, photopurification and biomass to create a positive energy balance with zero carbon emission.

As highlighted by Zamani at el.[1], Shimizu [4] reports that Green Float has a diameter of 3000m and uses the 1000m concept of vertical sky in the city. The concept introduced by Green Float is terraced community in the sky. It deploys tower characteristic featuring community housing, shop, restaurant and medical facilities. The tower concept provides an elevator of seven hundred meters and walking scale between workplace and residence. In the middle of the tower is a plant factory that is self-sufficient in food production. On the water side, facilities that build provide such marine city, airport, jogging zone, aquatic leisure zone a paddy agriculture area and field agriculture area. In addition, the conversion of drifting “garbage island” into the energy source concept and a waste recycling system have also been introduced. Bio business introduced, offer pharmaceutical market, food and cosmetic market, beauty and health market. OTEC is used as power generation that generates 30MW of electric power that need by 100,000 people. Other power sources are wave power and a solar power satellite in geosynchronous orbit that transmit energy to Earth in the form of microwaves. Fundamental safety from events such as strong wind countermeasure, wave countermeasures, earthquake countermeasure and lightning are taken care of using countermeasure systems.

As highlighted by Zamani at el [1], DeltaSync [5] describes a Seastanding mega-float as a combined concept of aquaculture and hydroponics to create a self–contained ecosystem in food production. An integrated multi-tropic aquaculture was introduced as the new concept for saltwater fish production that complete the metabolism chain of living population cities. For efficient water management strategy, rainwater collected and stored, seawater is desalinated and grey water is reused. The building’s roof and the floating platform are used to collect rainwater and stored in flexible tanks. The power sources that supply electricity for resident are Ocean Thermal Energy Conversation , wind energy and solar energy. Breakwater structure and a hinged connection for the floating structures is used concept as an element for the safety aspect against natural disaster.

Different between current concept designs are quite large. For a given set of mission, for example deep sea-exploration , differences on the five conceptual elements are noticeable. Details on design philosophies are not easily recognized. Primary functional facilities differs. Technical specifications not provided or sketchy. Method of estimating spaces and volumes provided not given or easily traceable to widely accepted standards. The research aims to establish an approach such that the design concept would serve as reference.

2.0 LITERATURE REVIEW

2.1 Megafloat and Liveability Issue

As propose by Zamani at el. [6], megafloat is an extended version of the conventional very large floating structure which Wang et al. (2007) correctly claims of having “many advantages including (i) cost effectiveness when the water depth is large and the seabed is soft,(ii) environmental friendliness as they do not damage the marine eco-system, or silt-up deep harbours or disrupt the tidal/ocean currents, (iii) their shorter construction time, (iv) easily removal, reconfiguration and reusing, (v) not affected by earthquakes as they are inherently base isolated, (vi) they provide scenic 360^0 view of the water body, (vii) their interior spaces may be used for offices, car parks and storage rooms and(viii) their constant position with respect to the water level make them ideal for use as piers and berths for ships.” While conventional VLFS has been proposed for various near-shore uses such as floating airports,bridges, breakwaters, piers and docks, fuel storage facilities, emergency bases, entertainment facilities,recreation parks and mobile offshore structures (Watanabe et al., 2004b) Megafloat removed very large floating structure’s dependency on shore-based supply thus creating total readiness for sustainable habitation. The immediate application of megafloat concept is of course to all potential OTEC installations for the 99 nations identified by Takahashi and Trenka (1996). He has included in his list countries where sites could be established for shore-based OTEC installations 10 km from shore so that installations are within the states territorial waters of 12 nautical miles. Applying megafloat’s concept to current OTEC platform design is quite straight forward for the OPeCS configuration could be coupled to the awaiting OTEC platform byengineering means.

As highlighted by Zamani at el. [1], Leby [7] describes factors that represent the quality of living and comfort which are sustainable in neigborhoods. Liveability dimensions that are crucial for neighborhoods include social, physical, functional and safety. Factors that influence liveability dimension are community life and social contact, environment quality, accessibility, feeling of safety, numbers of crime and accident, and maintenance of built environments. Lee [8] evaluates conditions that provide environmental liveability and benefit to the community by preventing disasters and sustainable subsistence. To evaluate liveability in the community, one must consider health, convenience, comfortable, secure and socioeconomic. Other criteria of environment livability can be availability of water, density of public facility, growth and development of the population, and agriculture resources.

2.2 General Arrangement Items on Megafloat

Naceur [9] describes the characteristics of shared outdoor spaces in housing estates influence residents to interact with one another. The facilities provide in housing estate are a primary school, a college, administrative buildings (bank, insurance company, police station, soccer field) and bus stations. Desley [10] describes household activities influence the perceived dimension of the neighbourhood: for example, how far people are willing to walk to public transport, banks, health facilities, shops and recreational facilities. Reiko [11] reports facility that availables in the Silver Peer Housing that make resident feel comfortable housing and a communal space open to public such as a bus stop or train station, clinic or hospital, post office, bank, grocery, and so on. Eziyi [12] analyzed the factor of resident satisfaction with the housing environment by location of housing estates, housing service, and social environment. The housing service criteria provide good facilities such as public infrastructure, health facilities, education facilities, sporting facilities, business, security and safety service. Lisa [13] compared three suburbs of different street network design: traditional, conventional and hybrid in term of useful amenities and daily need such as petrol station, post office, child care centre, and market.

MacDonald [14] considers a commercial building for specialized service and enterprise management exist in United State. The example of commercial building are bank, courthouse, shopping mall, fire station, police station, jail, laboratory, post office, vacant, convention center and religious organization. Buck [15] groups the building type of commercial sector includes a retail store, public admin, public hall and indoor entertainment and recreation. Ricardo [16] give example of the spatial structure of the Canadian in commercial sector are pharmacies, community centre and religious facilities. Matthew [17] classified commercial building types are financial service, manufacturing, retail and medical service. Nuri [18] categorized commercial building as office building include medical building, warehouse and financial building. Schleich [19] describes the sub –sector in the German commercial sector, such as bakeries, butcheries, car repair industry, laundries and dry cleaner, metal industry and bank. Mortimer [20] defines building consists in the commercial sector by reference to Standard Industrial Classification (SIC) for instance, hotel, air transport, postal service, sanitary service and banking.

Zhu [21] groups the industry sector for Chinese economy through agriculture, manufacturing, and service that include the farming, fishery, textile manufacturing, transportation service and telecommunication service. Zafer [22] analyzed the performance of energy for industrial modes such as chemical-petrochemical, cement, fertilizer and sugar . Raul [23] classified a large sized industries in city are food and beverage industry, cement and ceramic industry, glass and plastic industry, textile manufacturing,manufacturing of metal product and chemical – pharmacy industry. In addition, Pierre [24] analyzed the sector that covered in the industrial category are ICT service, transportation service and natural resources service. Jiansu [25] exploitation the industry that engaged in natural resources such as extraction of petroleum and natural gas, mining and processing of ferrous metal ores and non-ferrous metal, and manufacture of paper and paper product. Bujold [26] give example of industrial land based on printing and publishing and medical device such as pharmaceutical and medical manufacturing, newpaper and directly publisher industry, and motion picture and video industry.

Myriam [27] state sustainability of city sometime is being synonymous with having a public mission such as education, health , security and safety to work done by government. Anthony [28] asses innovation activities within national government through public administration, public service provider and publicly- owned commercial corporations. The example of public administration are fire protection, police, waste management, environment and health. Bogdan [29] also evaluate the performance indicator derived from the role of the government in providing opportunities to give benefits of public activities and public sector efficiency throughout public administration, education, health –care and public infrastructure. Ashley [30] describes government agencies responsibility to serve the public good to ensure lasting sustainability such as department of park and recreation, department of youth and community development and food department. Bernard [31] classification five cases of basic attributes by governance are education, healthcare, transportation, defense and justice. Ida [32] state that welfare service and water supply need to be recognized as a particular type of public service to the complexity of governmentally in considering the increase of development of the citizen.

Falin [33] groups the assessment of renewable energies includes, solar energy, wind power, wave energy, which are all commercialized and matured in terms of current technologies while other renewable energies, which have not proven as matured as the aforementioned ones such as ocean thermal energy conversion. Rodrigo [34] describes two basic ocean thermal energy conversion designs are closed cycle plants using an expanding working fluid to drive a turbine-generator system, and open cycle plants using vaporized seawater to drive the turbine. Young [35] describes the development concepts of the floating type photovoltaic energy generation system that designed, fabricated, and installed successfully at the sea site in Korea. Oriol [36]describes the offshore wind power plants can be connected by means of high voltage direct current system require a power converter at the entrance of the wind farms, allowing a centralized control for the whole wind farm like some offshore wind farms employ only this central power converter with squirrel cage induction generators or synchronous generators , while others combine a central power converter with individual converters and doubly fed induction generators in each wind turbine.

3.0 METHOD

Let total area inclusive of livability items is A_T. A_T is made up of sub area on the megafloat such as residential space, commercial space and etc. Hence,

$$A_T = \sum_{i=1}^{t} A_i \qquad (1)$$

Where ,

A_T = Total area of all main systems on that particular megafloat

A_i = Sum of main system area on that particular megafloat

i = Megafloat's main system or module such as residential space, commercial space, industrial space, government space , power generation space and etc

t = The number of main systems on that particular megafloat

For each A_i,

$$A_i = \sum_{j=1}^{u} a_j \qquad (2)$$

Where ,

a_j = Sum area of sub- component of main system on that particular megafloat

j = A sub – component of main system such as housing area, education area, security of life and property area, connected community area, public infrastructure and urban service area, business area, sport facilities and recreation for residential space.

u = Number of sub- system on that particular megafloat

But □ is the *m* of its own sub-component ā . Hence,

$$a_j = \sum_{k=1}^{m} \bar{a}_k \qquad (3)$$

Where ,

$\bar{a}_k$ = Sum area of sub- component of system *a* on that particular megafloat

k = Sub –component of system *a* such as housing estate, water supply area, electrical area and sanitary service area for housing area

m = Number of sub- component of system *a* on that particular megafloat

i.e

$$\bar{a} = \bar{a}_b \, x \, \beta \qquad (4)$$

$$\bar{a}_b = (a_c) x \, p \, x \, \beta \qquad (5)$$

i.e if demand factors is number of population (P), where $0 \le \beta \le 1.0$

$\bar{a}_b$ = Area benchmark value of sub- component of system a on that particular megafloat

a_c = Area per demand factor

p = Total demand by population

β = Liveability index

4.0 APPLICATION

When the formula (1) is applied expression in all space in megafloat it become:

$$A_T = \sum_{i=1}^{n} A_R + A_{CM} + A_I + A_{GV} + A_{PG} \quad (6)$$

A_R = Area for residential space
A_{CM} = Area for commercial space
A_I = Area for industrial space
A_{GV} = Area for government space
A_{PG} = Area for power generation space

When the formula (2) is applied expression in residential space it become:

$$A_i = \sum_{j=1}^{7} a_H + a_E + a_S + a_C + a_{PU} + a_B + a_{SR} \quad (7)$$

a_H = Area for housing space
a_E = Area for education space
a_{SP} = Area for security of life and property
a_C = Area for connected community space
a_{PU} = Area for public infrastructure and urban service
a_B = Area for business
a_{SR} = Area for sport facilities and recreation

When the formula (3 and 4) is applied expression in residential space at housing space it become:

$$a_H = \sum_{k=1}^{m} \bar{a}_{HE} + \bar{a}_{WS} + \bar{a}_{ES} + \bar{a}_{SS} \quad (8)$$

Where,
$\bar{a}_{HE}$ = Area for housing estate
$\bar{a}_{WS}$ = Area for water supply storage
$\bar{a}_{ES}$ = Area for electrical service
$\bar{a}_{SS}$ = Area for sanitary service

$\bar{a}_{HE}$ = Area per house x number of houses according to population
$\bar{a}_{WS}$ = Area storage water demand per house x number of houses according to population
$\bar{a}_{ES}$ = Area electricity demand per house x number of houses according to population
$\bar{a}_{SS}$ = Area treatment waste product per house x number of house according to population

When the formula (3 and 4) is applied expression in residential space in education space it become:

$$a_E = \sum_{k=1}^{m} \bar{a}_{CS} + \bar{a}_{PS} + \bar{a}_{CL} + \bar{a}_{MS} \quad (9)$$

$\bar{a}_{CS}$ = Area for children school
$\bar{a}_{PS}$ = Area for primary school
$\bar{a}_{CL}$ = Area for college
$\bar{a}_{MS}$ = Area for middle school

$\bar{a}_{CS}$ = Area school per student x number of students
$\bar{a}_{PS}$ = Area school per student x number of students
$\bar{a}_{CL}$ = Area college per student x number of students
$\bar{a}_{MS}$ = Area school per student x number of students

When the formula (3 and 4) is applied expression in residential space at security of life and property space it become:

$$a_{SS} = \sum_{k=1}^{m} \bar{a}_{PS} + \bar{a}_{FS} \quad (10)$$

$\bar{a}_{PS}$ = Area for police station
$\bar{a}_{FS}$ = Area for fire station

$\bar{a}_{PS}$ = Area of police station per police x police according to area coverage
$\bar{a}_{FS}$ = Area of fire station per fireman x fireman according to area coverage

When the formula (3 and 4) is applied expression in residential space at connected community space it become:

$$a_C = \sum_{k=1}^{m} \bar{a}_P + \bar{a}_L + \bar{a}_M \quad (11)$$

$\bar{a}_P$ = Area for postal service
$\bar{a}_L$ = Area for library
$\bar{a}_M$ = Area for mosque

$\bar{a}_P$ = Area of post office per postman x postman according to area coverage
$\bar{a}_L$ = Area of libary per population x number of population
$\bar{a}_M$ = Area of mosque per population x number of Muslim population

When the formula (3 and 4) is applied expression in residential space at public infrastructure and urban service space it become:

$$a_{PU} = \sum_{k=1}^{m} \bar{a}_T + \bar{a}_{TS} + \bar{a}_N + \bar{a}_{PS} \quad (12)$$

$\bar{a}_T$ = Area for public transport
$\bar{a}_{TS}$ = Area for train station
$\bar{a}_N$ = Area for nurseries and child care centres
$\bar{a}_{PS}$ = Area for petrol station

$\bar{a}_T$ = Area of public station x number of stations according to area coverage
$\bar{a}_{TS}$ = Area of train station x number of stations according to area coverage

$\bar{a}_N$ = Area per nurseries x number of nurseries according to population and

$\bar{a}_{PS}$ = Area of petrol station x petrol station according to area coverage

When the formula (3 and 4) is applied expression in residential space at business space it become:

$$a_B = \sum_{i=1}^{m} \bar{a}_{HC} + \bar{a}_{MT} + \bar{a}_{BK} + \bar{a}_{RS} \quad (13)$$

$\bar{a}_{HC}$ = Area for health care
$\bar{a}_{MT}$ = Area for market
$\bar{a}_{BK}$ = Area for bank
$\bar{a}_{RS}$ = Area for retail shop

$\bar{a}_{HC}$ = Area of clinic x number of clinic according to population
$\bar{a}_{MT}$ = Area of market x number of markets according to population
$\bar{a}_{BK}$ = Area of bank branch x number of bank branch according to population
$\bar{a}_{RS}$ = Area of retail shop x number of retail shop according to population

When the formula (3 and 4) is applied expression in residential space at sport facilities and recreation space it become:

$$a_{SR} = \sum_{i=1}^{m} \bar{a}_{PK} + \bar{a}_{LF} + \bar{a}_{SF} + \bar{a}_S \quad (14)$$

$\bar{a}_{PK}$ = Area for park
$\bar{a}_{LF}$ = Area for leisure facilities
$\bar{a}_{SF}$ = Area for sport facilities
$\bar{a}_S$ = Area for soccer field

$\bar{a}_{PK}$ = Area of park per population x number of population
$\bar{a}_{LF}$ = Level of sports facility provision per person x number of population
$\bar{a}_{SF}$ = Level of sports facility provision per person x number of population
$\bar{a}_S$ = Level of sports facility provision per person x number of population

Most unknown for ā will be obtained from standard value used for land base application.

5.0 DISCUSSION

The whole idea of this research is to establish a reference on how conceptual designing of megafloat should incorporate livability elements. It has been considered as an issue because providing livability items in the form of space and facilities on megafloats involve high cost since space as scarce. Additionally, current concept designs did not indicate how quantity for livability items such as space are estimated and incorporated into the concept design. The difference in livability items indicated if any, on the current conceptual designed poses questions about the consistency of its fundamental.

The approach proposed has been based on strong fundamentals set by MohdZamani [37] . He established eight livability element affecting conceptual designs of megafloats, ranked according to degree of importance and supplied with proposed types of livability items. Quantity for space area, for a livability item has been estimated based, for example, on benchmark values and proportioned according to its degree of importance reflected by the value of β.

As far as the estimation is concerned uncertainties are on the selection of benchmark values and the value of the degree of importance β. Current values considered as standards for similar but land – based projects could be used. Even so, a wide range of values exists for one particular livability item. Furthermore, standard used by countries around the world are different.The values are ethnic and culture related. Furthermore, there is always the possibility of mixing values from a different set of standard since certain values may be missing from the set of standard taken as the principal act. The biggest problem is to source the dynamic nature of livability itself. Lately livability has been defined around abstract concepts such as safe living, green, sustainable etc. Hence, a set of benchmark values considered as excellent could be the lowest livability standard 5 years from now. Those uncertainties should be taken care of appropriately.

Another issue is on choosing the values of β. This factor has been introduced to shrink the land –based benchmark values. The underlying argument is space on megafloat is scarce and costly. Since that a livability item by type or similar must be made available β will take effect on its quantity. What then should be the value of β for each livability items? Should the value of β be set hierarchically by group of livability items and later by elements in each group? Current observation seems to indicate that the most important livability element should be given the highest β value. If $0 \leq \beta \leq 1.0$ should the height β value be 1.0? If the limit for β between 0 to 1.0 is true which livability items qualifies for $\beta = 0$? It is quite easy to determine β arbitrarily. What then is the practical method of determining β? Should designer's chose on β be questioned?Answer to these fundamental questions will affect the quantity to be allocated for the livability items..

6.0 CONCLUSION

In an effort to solve the problem of lack of reference on method of identifying types and quantity of livability items to be provided on long term habitable megafloats the researcher has proposed an approach where values provided for similar land based applications are utilized after being resized by factors that correspond to the items' degree of importance. The approach proposed is found a mentally sound when applied in creating concept designs of megafloat it is expected to produce results with traceable argument and justifications.

Further works are required while current effort is focused on completing the formula for different module of the megafloat including benchmark and β values. The new research focus should be on addressing uncertainties in those values. The possibility of reducing uncertainties using fuzzy method should be explored. At the advanced stage the research should produce design specifications for livability items on megafloats after megafloat livability indexes have been establish.

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