Enhancing Food Security throughout Aquaponics in Urban Farming Development Strategy

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Abstract. Less waste in the activity of the aquaponics system implemented most as an innovative hobby that have given another benefit such as food security and sovereignty achievement at least by themselves, in addition to economically and health of the family in the household as well. This research aimed to know food security created by aquaponics in urban agriculture development strategy. The research method used SWOT and IE Matric Analysis. The result showed that there are some priority strategies such as upgrade any skill and knowledge deal with aquaponics, socialize system benefit, increase aquaponics yield consumption and consumer expendable, implement the food health by aquaponics system, upgrade smart agribusiness capacity to enhance distribution access, and procure lower start-up cost.

Keywords: Aquaponics; Food Security; Strategy; Urban Agriculture

1. Introduction
SDGs initiated by United Nation born 17 goals for the agenda until 2030 that legalize at September 2015 in New York[1]. Primarily related to the first and second goal for instance end poverty whatever, wherever and zero hunger, reach food security, improve nutritious food and also support/promote sustainable agriculture. For those SDGs is being in mutual accord to Indonesian Development Programs which are going through.

The first human being the primary need and become the fundamental right as well are the need deal with food[2][3]Anyway, it is a critical role to keep their availability and security in sustainable. Food, either as the primary need or as a human right play an essential role in life, human sustainability and also included nation stability as well. It is stronger feelings that currently, almost become practical mindset due to those all food we need can get by shop even though for sake millennial generation, they hardly recognize the performance of plant itself or how to plant, how to sow and ripe or harvesting. Therefore,[4] explained the people prefer to cultivation making is getting taper off, so, it needed some creativity to build interest and conscious thought that consumed food initially root of agricultural activity hence [3]the problem was getting more complicated due to high population...
growth, lands are getting less and taper off too but contrast to food demand. Without procurement and creativity, we always meet the need by import and then we depend on others.

Unfortunately, whenever we want to cultivate plants activity, needed land, whenever we want to plant fish. The consequences, we need twice land for both two kinds of plants and fish. Even though in the urban area which land limited due to the existence of building the office, estate, market, and needed pools and hardly left of land. Fast population growth concomitant with consumer demand for food contrast to taper off land had and food production. Creativity in agribusiness is the key to meet food problems. Hence the limited space and resources in urban, urban farming cultivation, for now, is a big deal, and deal with a food product of fish and vegetable[5][6][7]. Awareness toward cultivation at urban was background by needed of healthy life so, their food need prefer to organic food. Therefore organic farming system was fostered to meet the needs mentioned. The lesson from that is developed organics based farming system regarding combine both of two systems Hydroponic and aquaculture called aquaponics[8][7]. Aquaponics is global as a viable shape of agricultural alternative[9] financially as well.[10] Explained that Net-Benefit-Cost Ratio at the range 1: 30 until 1: 100 even though in high relative investment for the fish component.

Aquaponics technology are divided into two parts such as aquaculture and plant-culture technology at once. For those technology water and fish secretion waste could be used as fertilizer medium on the plant by aquaculture circulation and hydroponics technology[11] so, [12] called aquaponics system and achieved significant popularity as landless organic agriculture deal with produce fruits and vegetables coincide with aquaculture efficiently. Aquaponics was the urban farming technique that getting popular in the city that could accommodate the need while yielding high-quality fresh food for people in the city for a healthy life[13][14]. According to[13], this system was innovative and revolutionary farming method those integrated plant and fish at once and also effective system cost. They used the land yard or proof by doing a hobby to become an urban farmer. [15][16] Said that from these activities appeared to overcome food supply alternative for family, reduce family spends for home-based kitchen event according to[17] and [6] could give benefit commercially not only locally but also globally. Aquaponics system could be set up everywhere[18] by using yard and roof in house or office by doing hobby to be city farmer,[15] and[16] from this activity would become an alternative solution to provide food for family, save the money for kitchen need[19].

Furthermore maintain clean environment from pollution where according to [1] the city recently faced many environmental problems included the issues air and water quality, lack suitable of green area, heat capture excess, polluted heat water flowing and less of ecological biodiversity. Unfortunately, people were ignoring the potencies of urban agriculture to improve ecological sustainability in the city. This writing aimed to study the transformation of urban agriculture especially aquaponics activity. This matter also meant that we make real regarding SDGs initiated by the [1] that had 17 goals followed by 169 targets. Number 1 was to end poverty in all its form everywhere and integrated to number 2 was to end hunger, achieve food security and improve nutrition and promote sustainable agriculture.[20] emphasized that food sovereignty throughout aquaponics system have a great potential to address insecurity of food and nutrition.

2. Material and Method

The kind and resource of data used secondary data gained from any references. The used method was purposively by measure dominant sequence from the mentioned literature. The tool of analysis used SWOT matrix and Internal-External (IE) to strengthen explanation because according to[21][22] the proper management was as suitable as condition and information collected from resolving data or case analysis and also the strategy of farming. The early step was evaluation regarding internal and external factors influenced on aquaponics as innovation of hobby to provide healthy food from home. Internal factors consisted of strengths and weaknesses, whereas external factor included opportunities and threats in which would be grouped to identified and described. After all data grouping, then do the scoring of weight and rating those resulted in the value of Internal and external factor (IFE and EFE). Matrix coordinate value of IFE and EFE determined aquaponics position. Mentioned matrix
become the reference for SWOT matrix analysis regard to determining priority strategies of food sovereignty by aquaponics hobby innovation.

3. Result
The result can be seen at table 1 and table 2.

3.1. Internal Strategy Factor.
Table 1 was indicator of strength and weakness factor. The amount of strength factor was 2.67 while weakness was gained 0.23.

**Table 1.** Internal strategy factor of strengths and weakness

| Strengths | Load | Rating | Score | Weakness | Load | Rating | Score |
|-----------|------|--------|-------|----------|------|--------|-------|
| 1.2 different systems and commodities | 0.15 | 4 | 0.60 | 1. Human Resources | 0.03 | 2 | 0.06 |
| 2. Efficient | 0.15 | 3 | 0.45 | 2. Promotion | 0.03 | 1 | 0.03 |
| 3. Intensive | 0.14 | 3 | 0.42 | 3. Startup cost | 0.03 | 2 | 0.06 |
| 4. Quality | 0.13 | 4 | 0.52 | 4. Hobby-commercial | 0.05 | 1 | 0.05 |
| 5. Soilless medium | 0.15 | 3 | 0.45 | 5. Need daily management | 0.03 | 1 | 0.03 |
| 6. Shorten market and supply chain | 0.12 | 3 | 0.36 | | | |
| Sum | 0.92 | | 2.67 | Sum | 0.18 | | 0.23 |

3.2. External Strategy Factor
Table 2 explained that external strategy factor consisted of opportunities and threats. The sum of opportunities strategy factors reached 3.05. The threats strategy factors reached score by 0.08.

**Table 2.** External strategy factor of opportunities and threats

| Opportunities | Load | Rating | Score | Threats | Load | Rating | Score |
|---------------|------|--------|-------|---------|------|--------|-------|
| 1. New innovation | 0.15 | 4 | 0.60 | 1. Bored, Lazy | 0.02 | 1 | 0.02 |
| 2. There is one left if ones failed | 0.10 | 3 | 0.30 | 2. Business | 0.01 | 1 | 0.01 |
| 3. Trend Go green and Go organic | 0.15 | 4 | 0.60 | 3. Instable Economic Condition | 0.01 | 2 | 0.02 |
| 4. Healthier life style | 0.15 | 3 | 0.45 | 4. Human Resources | 0.01 | 2 | 0.02 |
| 5. SDGs | 0.15 | 4 | 0.60 | 5. Electricity Acesss | 0.01 | 1 | 0.01 |
| 6. Improve Climate | 0.15 | 2 | 0.30 | | | |
| 7. Smart Aquaponics | 0.10 | 2 | 0.20 | | | |
| Sum | 0.95 | | 3.05 | Sum | 0.05 | | 0.08 |

4. Discussion
4.1. Internal Factor Analysis
[19] Describe three integrated aspects that could not be separated in agriculture sustainability development in the city that (a) Social, agriculture in the center of the city as an achievement of sustainable development so havinga positive impact on the growth of the city and also as science and knowledge resources and cultural sustainability. (b) Economically, implementation of aquaponics could optimize conservative values for instance using agriculture, fisheries and livestock production as consumed row food[15] and distributed to people in the center of the city.(c) Environmentally, this idea was concerning environmental hit as long as implementation. Implemented this activity also become one of strive to deal with being green in the center of the city. Social and economic lead to equitable; Social and environment lead to bearable; Economic and environment lead to viable. Social, economic and environment lead to sustainable. But some included technology and policy.
1. **Strength**  
Aquaponics could provide food from home for the family had the strength such like high curiosity human resources and loved the challenge all about cultivation or farming; there at least were two commodities harvested fish and plant either vegetable or fruit[23][10][24][9][6][25]. Production of aquaponics is 100% organic that needed most of the people who live in a healthy lifestyle[26]. Aquaponics system more efficient due to production input especially land and nutrition[18][9][15] and business pattern itself carried out intensively so that could get result high in quantity and quality[15][14][13][23][8]. Aquaponics system is less or no need soil medium and land to grow the plant thus could become portable where ever want to set. It would be different if there were community movement to plant vegetable, fruit, and fish in each home. Public food need could be met by familyownself. Food security and sovereignty for household scale was created. Sum-score by 2.67.

2. **Weakness**  
[23][26]stated that aquaponics activity also has the weakness, such as high start-up cost than conventional (land-used) activity. The farmer had to learn first because it is the new system in the narrow land even landless, production was still unstable, less promotion and our mindset was still a negative stigma due to failure. There are almost still only hobby activities then counted the balance rarely. The other weakness was still need daily management to monitor productivity because they were still lazy to notice. Sum-score of weakness score by 0.22.

4.2. **Analysis of External Factor**  
Fundamentally, food sovereignty will lift the farmer in a marginal position. Aquaponics deal with planting fruit, vegetable and fish become solution lead to food vulnerable and maintain water quality at once[27]. The approach is more concern toward local culture and wisdom, therefore the farmer could plant their variety like most by their way, cooking by their taste because of place the high esteem in diversification as the local culture as to be. Food security supported toward agriculture patterns family based where they plant by their selves at their land (land to mouth). [28] The family farming that leads to food security was one of the ways to achieve food sovereignty and the strategy to end poverty and also was the human right[29]. Nevertheless, it needed the novelty that would distinguish as an integrated innovation in one agribusiness system[4][11] stated that application and set in different potential to install technology, sustainable impact to consider partially and toward complexity in the market, value chain, community, urban-rural infrastructure and policy setting, further research acquisition.

1. **Opportunity**  
The respect toward sustainable agriculture principal by biofiltration wastewater from the pool by plant[30] and the possibility to increase economic efficiency by organical vegetable product nutritious food. Aquaponics was an innovative food production system, and revolutionary as well[13] system were both different science disciplines aquaculture and hydroponics integrated systematically. Those were the sustainable method whose trend to go green and go organic that eco-friendly[31] by combined recirculatory and biofilter[27]. It had a big opportunity due to the lifestyle change to be healthier life because absolutely consisted of 100% organic and suitable for a healthy lifestyle. Product image made people were getting more conscious of healthy life and consume fresh organic vegetable, fruit, and fish in the daily menu[26]. Even though urban farming activity when carried out more seriously could meet food need in an urban area so could minimize food risk such as perishable, broken along transportation and technical troubles.[18] Stated that for the smart city could make aquaponics as innovative urban. The environment surrounding would be comfortable, cold and created microclimate could reduce carbon emission, contribute to city ecosystem health. It could make more aesthetical and reduced runoff from rainfall. In addition, green plants lead to be available fresh cool weather for the community and reduced heat island effect rate by carbon fixation in photosynthesis[26]. Score of opportunity achieved at 3.05.
2. Threats
Human resources, played the important role for both of weakness and threats because aquaponic is a modified revitalization and new insight, thereby feared to try. Similar product competition but non-organic had lower price whereas the product performance was likely. The consumer was getting critical to choose and decide the product instead[17]. Indonesia generally had the unstable economic condition that influenced on product price fluctuation and enables to increase production cost. The other threats according to[23][12] were aquaponics system needed circulation fluency and continuously in need of nitrogen transformation, so it needed electricity access. Sum-score of threats 0.08.

4.3. Analysis of Matrix Internal-External (IE)
The score of IFE Aquaponics provide food from home was 2.67 and score of EFE was 3.05. Both of those scores interpreted the position of aquaponic at quadrant IV internal, external matrix. These scores meant at the recent time that opportunities and threats in external factors were stronger the strength and weakness in internal factors (Figure 2). The forward strategies were integration and intensive strategy. Integration strategy was such as make some partnership, collaboration, the product could be developed to the city where the market place in order the consumer got product easier. Whereas backward strategy such the way aquaponics could set anywhere cite for locations, supervising and empowering urban farmer to increase production and distribution evenly. Intensive strategy carried out by used stakeholder, friend, kin, neighbor, and market to aquaponics product to live healthier. Foster innovation the various and attractive product and make the smart market based on market penetration and house consumption.

| Internal | External |
|----------|----------|
| High (3-4) | Middle (2-2.99) | Low (1-1.99) |
| I Growth throughout vertical integration (Grow and develop) | II Growth throughout Horizontal integration (Grow and develop) | III Turn around Strategy (hold and keep on) |
| IV Stability (Grow and Develop) | V Stability operation /program (Hold and Keep on) | VI Devastation Strategy (review, ripe ordivision) |
| Middle (2-2.99) | VII Growth through concentric diversification (Hold and keep going) | VIII Growth through conglomerate diversification |
| Low (1-1.99) | IX Liquidation (review) |

4.4. SWOT Matrics Analysis
The formulation was grouped to become strength – weakness, strength opportunity, strength – threats, and weakness - threats strategies.Strategy W – O considered through having the advantage of IT capacity that expected to be able to be start-up cost cheaper. Establishing aquaponics movement and training. Strategy S – O considered through raising of understanding about aquaponics, increasing production and consumption from our own home. Strategy S – T was to become an exciting and yielding activity and then could stabilize economically buy aquaponics system way. Whereas strategy W – T was to minimize weakness and avoid threats by doing foster innovation and making partnership among research institution, academician, practician, non governmental organization. Gaining the best result lead to superior, viable and vigorous seed on faced weather and climate change and also more adaptive, develop smart city, smart urban farming and motivate to sustain for next generation.
5. Conclusions
Aquaponics had a decent prospect to achieve sovereignty in healthy food characterized organic’s property within that foster to a healthy lifestyle. The strategy of priority by enhancing insight and understanding due to aquaponics related to food sovereignty, production, food from our own home, understanding and implementation how important food security and healthy food are, and then increasing economic stability and capacity in Technology of Informatics or digital instruments and cheap start-up cost and establish smart urban farming.

References

[1] UN2015. Transforming Our World: The 2030 Agenda For Sustainable Development, United Nation.

[2] Susilowati E, Oktaviani R, Arifin B, Arkeman Y. 2013. "The Decrease of Production of Indonesian Soybean and Efforts to Ensure the Certainty of the Vegetable Protein Supply: a Literature Review," International Journal of Information Technology and Business Management, vol. 9, no. 1, 29 January 2013.

[3] Yuwono T, Widodo S, Darwanto D H, Masyhuri I D, Somowiyarjo S, Hariadi S S 2016 Pembangunan Pertanian: Membangun Kedaulatan Pangan, Yogyakarta: Gajah Mada University Press.

[4] Setiawan I, Supyandi D, Rasiska S, Judawinata M G 2018 Pertanian Post Modern. Jalan Tengah-Vertikal Generasi Era Bonus Demografi Membangkitkan Peradaban Nusantara. Menuju Pertanian 5.0 Berbasis Agriecofacture., Jakarta: Penebar Swadaya.

[5] Kyaw T Y, Ng A K 2017 "World Engineers Summit – Applied Energy Symposium & Forum: Low Carbon Cities & Urban," Energy Joint Conference, WES-CUE 2017, 19–21 July 2017, Singapore.

[6] Love D C, Uhl M S, Genello L 2015 "Energy and Water Use of a small-scale raft Aquaponics system in Baltimore, Maryland, United States," Journal of Aquacultural Engineering, vol. 68, pp. 1-27.

[7] Pollard G, Ward JD, and Koth B 2107 "Aquaponics in Urban Agriculture: Social Acceptance," Horticulturae, vol. 3, no. 39.

[8] Love DC, Fry J P, Li X; Hill E S, Genello L 2014 "Commercial aquaponics production and profitability: Findings from an," Aquaculture, vol. 435, pp. 67-74, 2014.

[9] Foskett D, Food Security and Small-Scale Aquaponics 2014 A Case Study on the Northern Mariana Islan of Rota, Oregon: the University of Oregon Graduate School.

[10] Bosma RH, Lacambra L, Perina C, Poulie, J; Schwaner; Marie, J; Yin, Y 2017 The Financial Feasibility of Producing Fish and Vegetable through Aquaponics., vol. 78, Elsevier.

[11] Konig B, Junge R, Bittsanzsky A, Villarroel M, Komives T 2016 "On the sustainable Aquaponics," Ecocycles, vol. 2, no. 1, pp. 26-32.

[12] Wongkiew S, Hu Z, Chandran K, Lee J W, Khanal S K 2017 "Nitrogen Transformations in Aquaponics system: A Review," Aquaculture Engineering, vol. 76, pp. 9-19.

[13] Sungkar M, Akuaponik Ala Mark Sungkar Volume 2 2015 Jakarta, Agromedia Pustaka.

[14] Riawan 2018 Membuat Instalasi Akuaponik Portabel (1m²) Hingga Memanen. Jakarta, Indonesia: Agromedia Pustaka.

[15] Halim J 2018 Akuaponik Pekarangan, Jakarta: Penebar Swadaya.
[16] Budiana N S dan S F A 2015 Akuaponik Panen Sayur Bonus Ikan. Bertani di Lahan Sempit Ubah Pekarangan menjadi Kebun dan Kolam mini., Penebar Swadaya., 2015.

[17] V. Miličić, R. Thorarinsdottir and M. a. H. M. T. Maria Dos Santos 2017 "Commercial Aquaponics Approaching the European Market: To Consumers’ Perceptions of Aquaponics Products in Europe," Water, vol. 9, no. 80, pp. 1-22, 31 January 2017.

[18] Santos M J P L 2016 "Smart Cities and Urban Area – Aquaponics as Innovativ Urban Agriculture.," Journal of Urban Forestry & Urban Greening, vol. 20, pp. 402-406.

[19] Ula M, Saadah A, Muhammad K 2014 "Sustainable Agriculture System (Sac-S): Inovasi Konsep Pertanian Urban Sebagai Pembangunan Berkelanjutan Dan Upaya Penanganan Masalah Perkotaan.," in Pekan Ilmiah Mahasiswa Nasional Program Kreativitas Mahasiswa - Gagasan Tertulis 2014, Jakarta, Indonesia.

[20] Mehnun N, Lagerwall G, Senzanje A 2017 "Food Sovereignty for Food Security, Aquaponics System as a Potential Method. A Review," Journal of Aquaculture, Research and Development, vol. 8, no. 7, pp. 1-9.

[21] Rangkuti F 2014 Teknik Mem belah Kasus Bisnis. Analisis SWOT Cara Perhitungan Bobot, Rating dan OCAI., Jakarta, Indonesia: PT Gramedia Pustaka Utama, 2014.

[22] Sa’id R F, Gumbira E, Retnaningsih 2014 "Perencanaan Strategik Produk Hortikul tura.," Agribusiness Development Center IPB, Bogor, Indonesia.

[23] FAO, Somerville C, Cohen M, Pantanella L Stankus J, Lovatelli A 2014 Small-Scale Aquaponic Food Production. Integrated Fish and Plant Farming. FAO Fisheries and Aquaculture Technical, Food and Agriculture Organization of the United Nations.

[24] Filep R M, Diaconescu S, Costache M, Bedivan M M S, Badulecu L, Nicolae C G 2016 "Pilot Aquaponic Growing System of Carp (Cyprinus carpio) and Basil (Ocimum Basilicum)," Journal of Agriculture and Agricultural Science. Procedia, vol. 10, pp. 255-260.

[25] Puspita, D.C. 2019 "Kampung Akuaponik Kandri, inspirasi untuk bercocok tanam di lahan terbatas.," [Online]. Available: konsultan.com/kampung-akuaponik-kandri-inspirasi-untuk-bercocok-tanam-di-lahan-terbatas. [Accessed 14 January 2019].

[26] The Ecology Center 2016 "From Backyard Beekeeping To Roof-Top Vegetable Gardens, Community Spaces, Front Yard Orchards, And Window Boxes — Urban Farmers Grow Where They Are.," Theecologycenter.Org, Europe.

[27] A. Sagita, S. Wicaksana and P. N 2014 "Pengembangan Teknologi Akuakultur Biofilter-Akuaponik (integrating Fish and Plant Culture) sebagai Upaya Mewujudkan Rumah Tangga Tahan Pangan," in Proseding Seminar Nasional Tahunan ke IV Hasil-hasil Penelitian Perikanan dan Kelautan. TS-25., Semarang, Indonesia.

[28] Glopolis, Food sovereignty as a way to achieve food security: small steps in the Czech Republic towards agri-cultural production and consumption, 2016.

[29] Australia Urban Agriculture 2014, "Food sovereignty is the right of people to determine their own food systems.," [Online]. Available: http://www.urbanagriculture.org.au/information/urban-agriculture/food-sovereignty.

[30] Surnar S R, Sharma O P, Saini V P 2015 "Aquaponics: Innovative Farming," International Journal of Fisheries and Aquatic Studies, vol. 2, no. 4, pp. 261-263.

[31] Oladimeji AS, Olufegha S O, Ayuba V O, Sololmon S G, Okomoda VT 2018 "Effects of different growth media on water quality and plant yield in a catfish-pumpkin aquaponics system," Journal of King Saud University – Science, 2018.
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