Combining Transit-Oriented Development and Urban Agriculture Strategy on Constructing Urban Environment Sustainability, the Case of Taiyuan railway station, Taichung, Taiwan

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Abstract. Continuously increase urban population and urban spatial sprawl, under limited land development and urbanization, implementing Transit-Oriented Development (TOD) to improve urban spatial environment has become crucial on Taiwan’s urban sustainability and development plan. According to literature research, introducing urban spatial planning into urban agricultural approach, can increase urban green coverage ratio and reinforce green network. This study will depict urban agricultural development approach with the implementation of TOD planning method on Taichung Taiyuan train station as planning site, using Taichung urban planning and development plan guidelines, in accordance to TOD core development merging urban agriculture development approach to reinforce TOD planning detail in order to achieve the urban environmental sustainability.

1. Introduction

As global population continuous expansion, with development and changes through time to time, more people concentrate on the urban zone. According to UN’s 2018 Revision of World Urbanization Prospects., 55% of the global population live in the city/urban, and urban-population is foreseeing with an increased rate of 62% (54 billion).

In Taiwan, 78.2% of the population live in the city (2018), approximately 18.6 million people. With an estimation of urban population peak in 2041 (20 million) and 10% increase population (87.5%) in 2050 resulting rural populated with less than 3 million people. Under the urbanization, urban spatial and sprawl, diverse transit for mobilizing will increase in demand rapidly, with insufficient transit development plan, will derivate problems such as environmental contamination, traffic congestion, poor living quality and strong impact on urban spatial environment. Taiwan suffers from insufficient energy resource, spatial constraints, and vulnerable environment, if the local authorities do not envisage the impact of urbanization and propose relevant approaches may cause over-urbanization unfavorable and adversely urban environment sustainability.

According to 2020 Taiwan Construction and Planning Agency Ministry of the Interior’s planning, based on Taiwan governance goal for living spatial environment is to aim humanistic, resilient and
charming city, creating quality living environment; structuring accessible environment, improve living transit road system, and increase living space quality; promote fringe city development, induce population and industrial distribution.

Rail transportation advantages urban development, energy-saving, and carbon reduction; thus, rail transportation is an important developing project of Ministry of Transportation by reducing highway and road construction and by increasing rail construction, incorporate TOD concept, rail transportation is positioned as ribbon core development of urbanization, to compose transit connection, linkage, and multifunctional transit plan.

2. Literature review

2.1 TOD
TOD, the basic concept of an urban development plan to focus on traffic node of peripheral areas, to improve and maximize urban dweller’s transit demand and usage within walking distance, biking or public transport to create greater mobility with ease of moving around, and decrease usage of private cars to aim sustainable urban growth, main developing approach includes: [1]

1. Spatial arrangement.
2. Diversity land/site usage.
3. Friendly humanism transit environment.
4. Private transit containment policies.

This development model/structure cultivates a stainability development, effective and cost-effectiveness city, aiming to “increase urban function and re-utilizing site development,” “fringe area transit-environmental improvement,” “increase public facilities and open space,” improve public transit usage,” “combine and stimulate local industrial and economic development,” “implementing city revitalization” to enhance quality living style, land densities re-utilizing and renewal, and improve transit with effective sustainable urbanization and decrease inappropriate urban sprawl [2]. However, with unclear and unimplemented TOD strategies, may cause insufficient parking, traffic congestion, and improper land usage and problems. With consciousness on environment protection and sustainability awareness, Green TOD concept has been enhanced, embraced and introduced. Green TOD is a compound of TOD and Green Urbanism promoting environmental design, increasing and maximizing the effectiveness of energy resource by utilizing and constructing green buildings and compounding the natural eco-system, conserved area, and local communities in to urbanization development [3].

It is an environmentally friendly of TOD approach method Cervero & Sullivan, 2010. By utilizing public-transit development site, leads to ribbon expansion development of urbanization, reinforce living densities, and enables cities to be more corridor-oriented; Meanwhile creating unique and multifunctional station area with coexistence and integration of sustainability, technology, and environmental urbanization planning.[4]

In order to comply with Green TOD, preliminary is to evaluate the sustainability of transit system if:

1. Traffic transportation consumption rate should not exceed renewable and production rate.
2. Transit facilities non-renewable resource rate can’t exceed the new or alternative resource development rate
3. Transit facilities pollutant emission rate can’t exceed environmental absorption capacity[5].

2.2 Urban agriculture
Urban agriculture is a modern and trend practice of environmental greening and providing agro-food, recreational and experience urban realm under limit and constrained land and agricultural facilities. Since society started to be more sensitive to healthy aspects and engagement of food origins, urban agriculture serves the trend in demand for environment greening and renovation. Whereas most developed countries reconsider and recalculate the potential advantages and benefits of introducing urban agriculture to urban environment[6].
Under different subjected and social background cities, creates different models of urban agriculture; In the definition of urban agriculture 4 criteria must be met: [7]

1. Purpose: to become self-reliant in food production and consumption, accomplishing and educational and demonstrative environment sphere also creating, restoring and stimulating local economic development.
2. Spatial Area: urban agriculture be set within or adjacent urban area, including producing, processing, selling, cultivating, educating and sight-seeing activities.
3. Cultivation scale: urban allotment garden, business building, communities, and schools' roof, balcony, fence and wall, public facilities and pedestrian sidewalks are utilized accordingly.
4. Production technology: in-soil, raised-bed cultivation, hydroponic vertical farming, plant factory, aquaponics, vertical farming, and edible landscape.

Vertical Farming and Green Roof has been proved, through research and analysis, to be the most efficient way of increasing green coverage ratio on urban spatial environment. Taipei had promoted and incorporated with 13 communities “Resident roofing farming and ecological greening plan” by creating 46 sites of roof eco-farming, with total of 2160 square meter (sq m) greening environment, decreasing 67.8 thousand kWh electricity and 358 metric tons of carbon reduction; Green wall and vertical garden not only decorate the city but also help to reduce noise, polluted dust and purify air quality, and improve living environment.

Urban agriculture is a complex agricultural activity with core environmental issue to solve food safety, community development, environmental sustainability and development, land usage and planning and agro-food system. It promotes environment management, purifying contaminated soil and land, increasing green coverage ratio and also decreasing rainwater runoff & air pollution, and increase diverse biological and plant protection[8]. By creating public spatial environment under constraint land with urban agriculture can also decrease public maintenance expense[9], increasing local job opportunities, and fully utilizing available resources such as roof, roadside, and unused space.

3. Constructing TOD collaborating with urban agriculture application model

Taiwan’s rail system has built decades ago, unable to fulfill Green TOD application concept for urban renewal or redevelopment. This research aggregate and induce core value of TOD approach with urban agriculture for humanism development, land usage, transit node linkage, architect densely development, rationing spatial and public transit to de-emphasized TOD detail planning. TOD collaborating with urban agriculture application structure can refer to figures 1.

4. Field’s location analysis and improving strategic

Taichung Taiyuan station earliest core-periphery development area of Taichung with continuous increase in population.
Originated at North side of Taiyuan street, in cooperating the new viaduct MRT program, it is relocated and built at the intersection of Taiyuan street, Nanjing E. road, and Dongguang road, and completed on 2016. The new station located in between a densely and decentralized residential junction, with aged houses and undeveloped field and green land. The area contains pre-school to senior high school, west side of the station, are sole usage of land with classic residential housing with partially aged housing; On the other side, close to the river, are majorly business usage. With its convenient traffic location, Taiyuan train station’s potential to be highly developed as the sub-core transportation hub of Taichung city.

Based on population distribution, transit flow, open space, and activities nodes analysis, the station consists 4 problematic issues to be solved, such as spatial oppression, interstitial and inconvenient road design, green-belt dispersion, long distance between activate nodes. By using “Pattern Language” approaches (by Christopher Alexander) this research summarized with 11 improvement approaches such as: directing green spatial, open space, implementing and stimulate local business, spatial complexity and multi-service facilities, street space liberation and transfer, guiding open community space, minimized dependence of private automobile and scooter, greening walking space, transit convenient and traffic safety, add green building. According to the above improvement approaches we to draw up Taiyuan station developing strategy diagram, Through Figure 2, we can understand how Taiyuan Railway Station's surrounding area will develop through TOD collaborating with urban agriculture in the future.

Figure 2. Taiyuan station developing strategy diagram

5. Design achievement

Following TOD’s core development and planning, also including and utilizing TOD’s building bulk ratio bonus method, retreat surrender buildings, implementing Community garden、Institutional
garden, Edible landscape, Vertical Farming and Private Roof garden on residential, business and mixed-use area, conceptual diagram as follow figure 3 to figure 6.

Figure 3. Urban agriculture utilization in urban spatial concept diagram

Figure 4. Current Taiyuan station 3D sketch
6. Conclusion and suggestion

Sustainability has always been the main objective and goal for any urban renewal plan. Taichung Taiyuan train station bounded with aged urban space, along with increasing population, urban space is highly demanded. In order to achieve sustainability objective, implementing TOD is unavoidable. Recent years, Taiwan government continuously complying TOD development method but never profound discussion on TOD development coalesce with urban agricultural, thus this study select the most feasible and adoptable model approaches by corresponding these approaches to TOD core development, the application of edible landscape are used relatively, mix-usage of land approach can include diverse urban agriculture practice. Corresponding urban eco-system evaluation indicators, land for ecological service and average green land per citizen are highly affected. TOD and urban agriculture with urban eco-system environment affected structure can refer to figures 7.
Under Taichung urban development plan guidance, this study in accordance with TOD core development composing urban agriculture development demand, reorganizing and re-rationing land usage is deliberate as follow:

1. Residential area
   Site measurement with more than 1000 sq m should reserve 300 sq m. for public area and facility, with minimum of 8 meters open space or non-roofing plaza either side of measurement. The public area can be children's' playground, recreation park, parking lot, plaza, green-field. Statutory open space enable application additional 60% of building bulk ratio of total area measurement; establishing green building with 60% or more green coverage ratio, enable with max. 5% building bulk ratio bonus.

2. Business area/district
   Business district buildings should be planned with 8 meters access road, no arcade but more than 2 meters of open space from the building line, among with preserving of min. of 2 meters non-roofing sidewalk. Including capacity transfer, open space, public facility, green building, and building bulk ratio bonus, should not exceed 1.5 times of site measurement. Site measurement with more than 500 sq m building should hold up to 1/2 of total site measurement enable to apply 20% of building bulk ratio bonus.

3. Greenbelt zone
   Site area with more than 1000 sq m, open space & green coverage ratio should reach more than 65% of total measurement, arbor and shrub plants should occupy more than 30% of green coverage ratio, meadowland & flowering grass should occupy more than 40% of green coverage ratio, automobile lane & green space segregate with 90 cm height hedge plant to increase natural environment educational site. Green parks defined, land or water, are the domain which enables in providing, maintaining, keeping plant growth and ecosystem, landscaping, disaster prevention, and recreational open space.

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