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Taiwan Brownfield Redevelopment & Ecological Restoration Indicator Analysis

S J Feng^{1,2}, N C Chao² and Y J Chen²

¹ Department of Architecture, Chaoyang University of Technology, 168, Jifeng E. Rd., Wufeng District, Taichung, 41349 Taiwan

² Department and Graduate Institute of Architecture, Chaoyang University of Technology, 168, Jifeng E. Rd., Wufeng District, Taichung, 41349 Taiwan

fengshyhren@yahoo.com.tw

Abstract. Adjustments in global industrial structure accompanied with urbanization, lead in result of derelict sites and lands initiated as manufacturing and production industrial. In which underlies not only creation waste in resource and energy, contaminated soil, damaged ecosystem, urban landscape changed, but also inhibits urban persistent development. Under the extensive aegis of environmental protection, people are highly attentive on brownfield impacts from surrounded life sphere; In Taiwan spatial reutilizing planning approaches are the mainly impetus for brownfield redevelopment programs, having very little or no incorporation on ecological methodology rehabilitation into the program. In this paper, we will elaborate the possibilities of sustainable development for brownfield redevelopment utilizing ecological restoration methodology in 1. preserving the industrial asset, in the meantime restored the ecological urban environment, 2. Initiate a structure framework suitable for brownfield's (industrial sites) ecosystem redevelopment evaluation indicator to maximize the value of brownfield in spatial & urban planning.

1. Introduction

Taiwan, till today, experienced decades of high economic grown and urban development, yet the structural had changed[1]. Back in 1950 ~ 1980, under the fast-industrial growth in Taiwan, lots of industry buildings and sites were implemented lead to continuous land development in the urban with ignoring the importance of environmental protection had cause displacement pressure moving peripheral areas during the urban sprawl process resulting turn downs in the urban metropolitan. Along the ages and industrial structural transformations, with lots of industries had migrate offshore, derelict industrial plants and sites with contaminated soil are derelict or underused. Overviewing on recent researches and literatures on landscape ecological theory, industrial heritage, ecosystem restoration, further discussion and analysis to explore brownfield's ecological restoration (henceforth ER) evaluation hierarchical structural framework inducing important indicators ER under contextualization process.

2. Literature review

2.1. Brownfield's Formation and Definition

Initially the first era of industrialization, In Europe at early 18th century, USA at late 18th century[2], under general urban development trend, industrial building and sites were set urban locations; taking into account the ongoing consumption of lands increase urban sprawl to meet up the fast growth of in-



dustrialization. Under urban economic and culture change, derelict or underused buildings, lands, fields are the irrevocable consequences from the extensive industrial development of the early stage. Early brownfield problems didn't bring attentions and concerns to the society, with the increase of environmental protection awareness, more and more attentions on restoration and redevelopment brownfield are being discussed. Brownfield management and redevelopment not only provide community financial revenue increase, employment opportunities but also benefits socio-economic and environmental health development creating a win-win outcome for both economic and environmental[3].

Due to offshore migrate industries causing derelict and underused sites exacerbating urban development accompanied further urban structural changes (community unemployment raises), industrial restructuring (decline in traditional industries), contaminated environment (toxic chemicals remained in soil). For the past decade, Taiwan were very aggressive in promoting secondary & tertiary industrial sectors which led to major polluted incidents and sites. According to Taiwan's industrial development characteristics and features of brownfields, there is a significant difference in between Taiwan and foreign brownfield's dimension and locations. In foreign, extensive scope of metropolis area likely are regarded as potential brownfield sites[4]; As per Taiwan, brownfield are sole derelict factories and sites that are located in peripheral locations of city development planning zones.

2.2. Regeneration of Brownfield

The existence of brownfield implies problems in shattering urban spatial and function disappearance, waste on urban development resources, increase in crime rates, economic depression, contaminated environment. The aim of brownfield sustainable redevelopment approach is to incorporate urban spatial development restoration and functions to benefit city's public facility services and disaster prevention function, meanwhile fulfill today & future economic and social needs. "European Urban Environmental Brownfield Sustainable Development Plan" describes brownfield sustainable redevelopment approach as a managing and restoring usage of land in order to ensure humanity's current and future demand under acceptable environmental sensitive, economic and social system within its location scope. The benefit of brownfield redevelopment releases pressure of overconsumption of lands and re-utilizing lands, stimulates economic revitalization & growth, and improves social environment quality, aid positive effect on ecological environment and humanity health[5]. Consolidation of diverse researches' aspects of brownfield redevelopment features, referred in Figure 1:

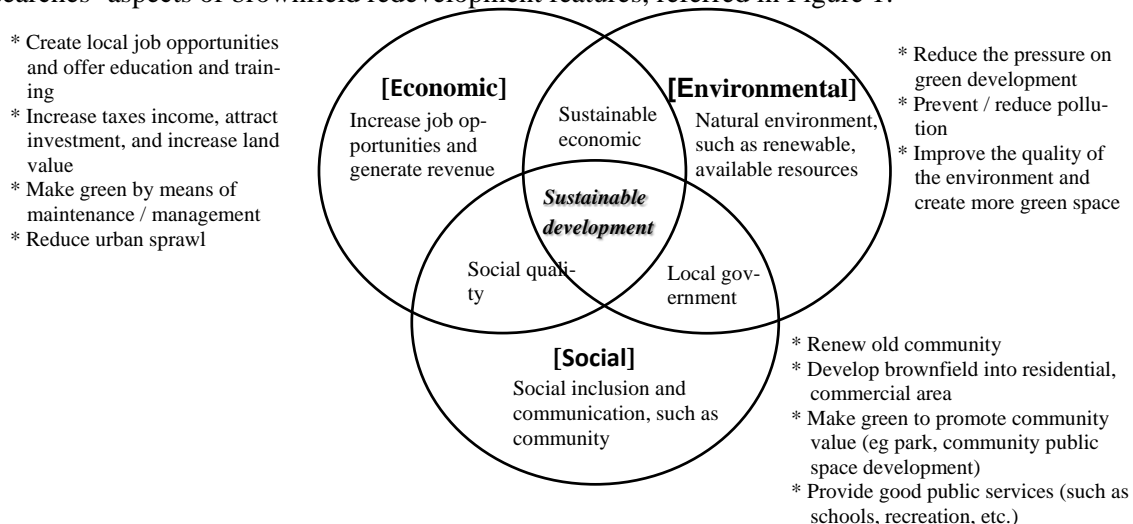


Figure 1. Regeneration of brownfield

2.3. Ecological Rehabilitation

The term "ecological rehabilitation" includes forest, ocean, wetlands and natural environment. Extant ecological rehabilitation structure framework is built up with full-sided, completed, and combined as-

pects indicators. Creating or restoring a historic environment yet excluding its initiative ecosystem function, the functions/approaches are just artificial structures which does not convey the ‘rehabilitation’ feature. Thus, the term ‘rehabilitation’ ought to include human historic heritage and natural environment restoration.

3. Methodology

This study, through literature review, interviews, case evaluation and analysis, constructs the reviewed regeneration evaluation frameworks of brownfield, and applies Fuzzy Delphi Method for induction on reviewed indicators, and afterward analyzes and probes into the relative weights between the indicators, for the reference of the follow-up study on construction of evaluation indicators for brownfield regeneration. Furthermore, the study, through the in-depth interviews with experts in various relevant fields, explores their opinions and advice on brownfields regeneration policy, and collects the first-hand information from their abundance of knowledge to enhance the depth and breadth of this research.

4. Industrial derelict ecological rehabilitation case analysis

4.1. Ruhr Industrial Area, Germany

Table 1. Ruhr Industrial Area, Germany rehabilitation methodology analysis:

Methodology	Description
Securing sewage and drainage of floodwater	Establishing bio-sewage water filtration station and utilizing micro-biochemical to purify raw & dirt waters.
Wind energy utilization	Utilizing wind energy to form a water recycling circulation program such as pumping and discharge purified water through water channel to the higher landscape for dry season irrigation; restore additional waters into overflow retention tanks.
Industrial disposable recycling	Utilizing industrial waste residue to pave roads, city squares, and rebuild clean water.
Plant protection	Organic plants are special selected for a indulging biological succession to remediate the environment brought by the industrialization damage.
Soil remediation	Removing the 2.5 meter depth of contained soil, burn it then refill with new soil.

4.2. Gas Works Park, Seattle

Seattle’s Gas work park is an example of “cleaning and greening” approach, introduced by Richard, Haag, implementing the idea of bio-phytoremediation method includes detoxify soil, utilizing natural laws optimizing ecosystem, selected plants, incorporate and reuse existing industrial features. Transform existing industrial remnants from old and obsoleted plant and machinery into aesthetic value. Having “minimized intervene, self-recovery” as basic concept and valuing the historical significance of the site, the designed concept preserved the industrial structure reaching man-nature balance status and restoring its ‘historic, esthetic and utilitarian value’. The recovery methodology as per table 2:

Table 2. USA Seattle, Gas Works Park recovery methodology analysis:

Methodology	Description
Soil remediation	Analyzing the contaminant substance and introduce enzyme that will able to breakdown contaminant and increase the natural bio-organism nutrient back to the soil. Utilizing biological and chemical to clean the pollutant area.
Utilizing nature bio-ecosystem remedy system	Introducing a nature way, ecology system, instead of expensive technological techniques to remedy the contaminate soil.
Plant Selection	Installing special plants, nitrogen-fixing plants are fast growing, with strong adap-

	tion and excellent survivability, that help to reduce, recover or remove contamination from the soil.
Industrial remnants reutilization	Having “minimized intervene, self-recovery” as basic concept and valuing the historical significance of the site.
Resource and substance utilization	Respect of historic heritage and landscape and ecosystem development effect by utilizing existing resources and substances when redeveloping the derelict remnants

5. Ecology Restoration methodology and indicator framework establishment

5.1. Ecology Restoration Evaluation

Going through literatures and research analysis on ecological integration, according to “The Society for Ecological Restoration (SER)” definition, including bio-diversity, ecological process and structure, territorial and historic transformation, persisting environmental practice on brownfield’s ecosystem rehabilitation can be categorized in to 3 aspect, ‘environment greening’, ‘water vitalization’, and ‘soil purification’. See table 3

Table 3. Ecosystem Rehabilitation Indicator Assessment

Goal Layer	Layer 2	Description
Ecosystem Rehabilitation Indicator	environment greening	Reburned plants are result from nature plant species transformed, competed and adapted environment. These plants will attract wild animals to habitat. Respecting the natural ecosystem mechanism balance in the field.
	water vitalization	Utilizing plants, animals or chemicals to filtrate and purify sewage. Reuse industrial water channels to form a natural circulation river channel can improve flooding control ability and restore underground water source, providing a habitant environment for the wild animals.
	soil purification	Waste reutilizing with landscape design. Disposable material reuse to reduce impact to the environment. Planting plants that help to get rid or reduce contaminant. Through bio and chemical actions to purify the contamination and revitalize the soil.

5.2. Industrial Derelict Ecosystem Restoration Indicator Establishment

Through above Ecosystem Rehabilitation indicator assessment, generalized from literature and cases analysis on indicator factors and subjected to expert open interview under restrictions, we convergence 12 assessment indicators, describe as follow:

5.2.1. Environmental Greening Indicators

- Green master plan: Utilizing green plants to fully cover the building walls and rooftop.
- Nitrogen-fixing plant: Installing special plants, nitrogen-fixing plants are fast growing, with strong adaption and excellent survivability, that help to reduce, recover or remove contamination from the soil.
- Greening landscape: utilizing nature plants to cover and bound with the soil providing plants and animal growth.
- Biodiversity Land: planting plants that will attract butterflies, and establishing a top-mid-bottom structural (top green, bottom woods, ground planting on layers), considering a complete environmental ‘ecological pyramid’. For Example, making sure that the survival spatial on bottom living being organism environment is suitable for toads or centipedes which depends on fungi or moss grown on dead trees. Ensuring the flow of ecological pyramid circulation, provides abundant food basis and assess biodiversity environment.

5.2.2. Water Vitalization Indicators

- Restoring natural river channels: reuse industrial water channels to form a natural circulation river channel can improve flooding control ability, restore underground water source, for-

mation of ecosystem habitation environment and environment landscape, and recreating natural leisure parks.

- Water preservation station: The ability to preserve water from natural or artificial method, the better the preservation station establishment is, helps the activation of microorganism on the soil and nourish plants improve organic qualities, and maintain base natural ecosystem environment balance.
- Sewage recycling circulation plan: establishing a complete sewage and water recycling system to filtrate industrial waste and urban sewage water reaching a recycling and reuse of water.
- Waters biodiversity: cross-interaction of river corridor and trough, beach and river edges forms an ecosystem; river corridor ecology quality reflects riverbed's biodiversity and water quality forming an rich water biodiversity habitat.

5.2.3. Soil Purification Indicators

- Disposable handling: categorizing and handling should be taking extremely care to prevent any disposable leaking sewage that pollute ground soil and underground water and enhance living environment quality.
- Recycling on waste: waste that are not handling properly and buried underground, contaminate soil/land. In order to reduce the waste impact to the environment, waste materials should be reutilized.
- Plant rehabilitation: Utilizing the plants characteristic to absorb contaminant and heavy metal aiming to reduce, remove and restore the contaminations on land/soil.
- Improve soil contamination: using biochemical regenerating and improve polluted soil by adding humus accumulation, increasing microorganisms, soil mixing methodology, chemical stabilization techniques, acidizing soil method and soil dressing method.

5.3. Weighting Indicator Analysis

Through expert censuses, participant from industrial, government, and scholars with abundant understanding and knowledge on urban brownfield redevelopment, ecosystem rehabilitation, and industrial derelict & environmental landscape planning, introducing AHP into analysis procedure result data from the weighting each indicator are shown below, table 4. (total of 13 censuses, 11 received completed, 2 invalid)

Table 4. Indicator Level weighting and ranking

Aspect	Indicators	Relative Weight	Relative Rank	Absolute Weight	Absolute Rank
environment greening 0.3980	Green master plan	0.2043	12	0.0813	8
	Nitrogen-fixing plant	0.2535	5	0.1009	4
	Greening landscape	0.2575	4	0.1025	3
	Biodiversity Land	0.2847	3	0.1133	1
Water Vitalization 0.2386	Restoring natural river channels	0.2364	8	0.0564	10
	Water preservation station	0.2245	10	0.0536	11
	Sewage recycling circulation plan	0.3227	1	0.0770	9
	Waters biodiversity	0.2163	11	0.0516	12
soil purification 0.3634	Disposable handling	0.2394	7	0.0870	6
	Recycling on waste	0.2433	6	0.0884	5
	Plant rehabilitation	0.2311	9	0.0840	7
	Improve soil contamination	0.2862	2	0.1040	2

6. Conclusion

6.1. Brownfield Recovering Impacts

For the past decades, industrialization had contribute country growth significantly, set up the first mile-stone on industry economic. Yet, through industrial structure changes, many industries are facing the decision of shutdown and offshore migrate, resulting contaminated brownfield. Considerations should be taken on redevelopment and transformation of brownfields, meanwhile, soil recovery and purification should be following foreign standards under environmental protection; letting brownfield redevelopment program bring good influences to its community development. Considering Taiwan land limitation and throughout literature studies and experts' view, understanding the formation of Taiwan brownfield and its redevelopment impact, not only concentrating on influence environmental quality and increase polluted problem-solving skills, but also reconsidering rigorous plans and developments on restoring the land, enhance economic activities and social impact.

6.2. *Ecosystem Indicator Restoration Methodology*

- Biodiversity Land: creating soil porosity environment, not influence or interference by humanity, with layers of eco-green environment creating habitat for biological organisms, plants, animals to protect and rich green infrastructure.
- Improve soil contamination: regenerating land and soil with 2 methods: 1. Change existing-heavy metal type to stabilize and reduce its mobility. 2. Remove heavy metal by any method. The best method is to dig the contaminate soil then utilize the micro-biochemical to sink edible bacteria for biochemical treatment. Or remove and burned the polluted soil.
- Green master plan: Leaving big space for greenfield, then plant palm trees and shrubs. Density of planting can be increased to fulfill multilayer of greening function.
- Selection of nitrogen-fixing plant: nitrogen-fixing is a nutritious circulation method. Lots of plants, specially leguminous plants, contains nitrogen that nourish and fertilize other organism. Nitrogen also help to adjust critical ecosystem environment. Large nitrogen trees such as: acacia, albizzia julibrissin, senna, golden shower, pigeon pea, king wook, cocksaur coral, muntingia calabura. Small nitrogen plants: cassia minosoides, horse bean, peanuts, soy bean, mimosa, lucern.
- Recycling on waste: utilizing industrial waste residue to pave roads, city squares, and rebuild clean water.
- Disposable handling: providing spatial environment landscape to handle disposal and establish recycling categorizing system program.
- Plant rehabilitation: Utilizing the plants characteristic to absorb contaminant and heavy metal aiming to reduce, remove and restore the contaminations on land/soil.
- Green master plan: Utilizing green plants, such as longiniaceae, to fully cover the building walls and set gardening on rooftop to increase greening.
- Sewage recycling circulation plan: establishing a complete sewage and water recycling system separating the sewage and river stream, utilizing micro-bioorganisms to purify sewage will help to reduce contaminant and prevent harmful and adverse effects to ecosystem quality.
- Restoring natural river channels: remove concrete from all the river channel, utilizing natural material for buildings and cooperate with ecosystem construction legislation to recover the initiative natural ecosystem mold.
- Water preservation methodology: adding soil area, greenfield helps to preserve rainwaters and also nourish plants will be the most natural way of environmental protection; increasing water penetration pave, excellent penetration pave functions as soil/land; restoring penetration design, a pool/dam/station that facilities preserving waters from rainfalls, outflow back to soil will help increasing soil density in prevention of flood and mudslide.
- Waters biodiversity: cross-interaction of river corridor and trough, beach and river edges forms an ecosystem; river corridor ecology quality reflects riverbed's biodiversity and water quality forming an rich water biodiversity habitat.

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