Development of an edutainment shaft garden for integrated waste management in the UGM green campus

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Abstract. Biomass productivity and organic cycles in tropical regions are the highest in the world because of increased temperature, rainfall, humidity, and sunlight year-round. Organic waste not only comes from the agricultural sector (agriculture, horticulture, plantation, forest, livestock, and fisheries), but also from non-agricultural entities (cities, market, offices, households, campuses, industries, and other sectors). Organic waste volume from the integrated campus UGM yard reached 30 tons/day, requiring the support of adequate self-managed waste management facilities. Various experimental approaches were used in designing the Waste Management Centre at UGM as part of an edutainment (education and recreation) program. The problems at the Waste Management Centre included (1) an integrated system of recreational functions in biogas and compost processing; (2) high operational costs; and (3) space efficiency for productivity and processing. Development of a ‘Shaft Garden’ was chosen a solution for (1) creating visual attraction and space experiences from biogas and compost management; (2) utilizing gravitational force as a utility distribution system; and (3) creating a sequence of spaces according to the function. Integrated organic-cycle management by empowering the 9R (Reuse, Reduce, Recycle, Refill, Replace, Repair, Replant, Rebuild, Reward) framework with a multi-function and multi-product approach has provided higher value-addition to environmental, economic, socio-cultural, and health aspects.

1. Introduction
In Indonesia, natural resources are considered ancestral heritage, and resource development is carried out primarily by relying on natural resource manipulation [1,2,3]. Therefore, a new paradigm to empower land resources (soil, water, mineral), biological resources (plants, animals, human), and environmental resources [4,5] is required. Knowledge-based development should be supported through innovative science and technology, labours, and invention, in addition to smart, innovative, broad, profound, and futuristic concepts of sustainable development [1,6,7].

Environmental protection and waste management are two complementary ideas to understand the nature of action and its consequences [5,8]. Municipal Solid Waste (MSW) is a complex environmental problem source and also a potential source of renewable energy [9]. Indonesia, with a
population of approximately 242 million, consists of 34 provinces, 17,500 islands, and a total area of 1,890,000 km², and is vulnerable to environmental impacts. The average municipal solid waste production increased from 0.8 to 2.1 kg per capita during the last decade with almost 550 solid landfills [9]. The increase in the amount of municipal waste could be overcome by optimizing the 3Rs (Reduce, Reuse, and Recycle) and with WTE (Waste to Energy) programs simultaneously [10].

Currently used waste management practices are inadequate to handle the waste produced. Today’s global economic crisis also demands a solution that does not only address the business sustainability, but also the political, environmental, social, and cultural sustainability [11]. Multi-stakeholder participation, support from top management, and industry collaborations are key factors encouraging the development of sustainable waste management models in the campus [12].

Sustainable Blue Earth Concept offers creative opportunity and novel innovation through the acceleration of natural cycle processes of available natural resources. Even the abandoned resources have added value to the economy, environment, socio-cultural, technological, and sustainability management [1,6]. Blue economy offers investment efficiency, increased innovation, increased funds, more jobs, social capital development, and entrepreneurial stimulation. It is realized by using garbage and abandoned goods and converting them into food, energy, and work. Thus, it transforms poverty into sustainable development, and transforms scarcity into availability [1,5].

In order to support the concept of organic waste management within the learning system of Blue Campus Universitas Gadjah Mada (UGM) Yogyakarta, designing an innovative edutainment for organic waste management in UGM Green Campus is of paramount importance. This study is expected to be a conceptual foundation for planning and designing an integrated innovation framework of both agricultural and non-agricultural sectors in the Green Campus waste management, encompassing the functions of education, research, social empowerment, leadership, and recreation.

2. Materials and methods

![Fig. 1. Diagram of Problem Formulation Integrated Waste Management](image)

The present study was carried out using primary and secondary research data. Primary data were collected from observations and field interviews. Secondary data were obtained from reports, books, journals, and the internet, and included theories, precedents, and standards used in the field (Fig. 1). Qualitative and quantitative analyses of the collected site data are ongoing to identify solutions for similar problems. The experimental plan may cover the physical experimental design and systematic
experimentation. The experimental plan involves process planning, budgeting, potential marketing, and implementation.

3. Results and discussions

3.1. Development of university farm

UGM Yogyakarta with the support of The Rockefeller Foundation in 1975 has built a 35 ha University Farm (Figure 2a) for agricultural education, research, and development [5]. Agus [1,5] developed the integrated bio-cycle farming system (IBFS) through an in-depth study by considering the following aspects: integrated plant, nutrient, pest, and water management [1,5]. An integrated organic cycle management facilitates the independent and qualified closed cycle system. Integrated landscape ecology management and the agropolitan concept are strategies for self-reliance and common participation, and they do not lead to competition or conflicts among individual sectors, and instead synergize them [1,5].

Both, the integrated cycle management and nature, tend to prioritize aspects related to the environment—aesthetics, society, culture, and economic values—so that they are in harmony and balance. Cultivation of life gold on Earth is designed to produce multiple products from a single unit of land in the form of life gold that is not assessed and neglected, including brown gold (wooden boards), yellow gold (rice grains, and corn as carbohydrate sources), and black gold (organic fertilizer and compost). Besides producing blue gold (biomass energy and biogas) and green gold (green vegetables, feed, and environment), it also produces white gold (milk, and fish), red gold (beef, chicken, pork, and duck meat), and clear gold (living water). Moreover, transparent gold (oxygen) and colour gold in the form of herbal medicines are very important for human health and for leading a dignified life [1,5,6].

Integrated waste management for the independent campus has been strengthened by constructing the Waste Recycling Laboratory in the University Farm at UGM as an integrated and sustainable waste management model to support zero waste in the UGM Blue Campus [1]. UGM performs separation,
sorting, composting of organic waste, and in situ/ex situ waste management using the 9R program (Reuse, Reduce, Recycle, Refill, Replace, Repair, Replant, Rebuild, Reward) through the development of decomposers, vermicompost, bio-gas, liquid fertilizers from livestock urine, and liquid fertilizer leachate, in addition to processing waste for energy, processing plastic waste for accessories, carbon emission, waste characterization, and composite waste management [1,13]. However, UGM waste management has still not been effective and efficient, as evidenced by the large amount of garbage dispatched to the final landfill site in Piyungan [13]. An effort to redesign the University Farm is required to enhance its role in Tri-darma (the three pillars of mandatory tasks) of Higher Education, which consists of education, research, and community service.

The plan to develop the spatial pattern of UGM University Farm can be divided into 15 zones as follows: (i) Archipelago Orchid Innovation zone (IAN), (ii) Archipelago Fruit Innovation (IBN), (iii) Energy Garden Innovation (IKE), (iv) Farming Organic Innovation (IOF) (v) Animal Feed Innovation (IPT), (vi) Critical Land Recovery Innovation (IPLK), (vii) Food Agricultural Innovation (IPP), (viii) Recycle Innovation (IRC) Waste Recycling Laboratory (LDUS), (ix) Exotic Animal Innovation (ISE), (x) Water Resource Management Innovation (IWRM), (xi) Post Harvest Laboratory (LPP), (xii) Teaching Research Farm (TRF), (xiii) Edupark-outbound, (xiv) Conservation Plant Development, and (xv) Green Belts located on the banks of Opak River (Fig. 2).

3.2. Case study

3.2.1. Sydhavns Recycling Centre Copenhagen, Denmark
The 1500 m² waste and recycling management centre has been designed with utilitarian facilities that are located far from the industrial city area. These facilities are designed by Bjarke Ingels Group by developing the concept of ‘Attractive and Lively Urban Space’ in an urban environment [14]. The activity zone in this design consists of a recycling centre existing under the fitness facility, a running track, and a picnic area. The shape of the building takes the form of a circle, which is space-efficient, as the curved area could be used for circulation and parking.

3.2.2. Pig City di Maasvlakte, Rotterdam, Holland
Pig City’s design focuses on combining organic farming and production activities, so that there will be enough space for other activities [15]. The unified production house design may minimize transportation and distribution needs, in order to reduce operational costs and the spread of disease. The building is vertical with a smaller footprint, and the design of the animal farm is not always horizontal and conventional.

3.2.3. Super market Sanya Lake Park di Sanya, Hainan, China
The design of the 2000 m² building includes the main attraction of the landscape—a large park as the corridor in each floor. The supermarket facade is closer with smaller shops that are more lively and conveniently located underground [16]. The landscape area is the main attraction to visitors and is arranged in tiers. The building has a bulge in the garden levelling located on the roof top with a special provision for a prospective super-market as visitors pass through the area.

3.2.4. De Wilde Plek di Delft, Germany
De Wilde Plek is a kindergarten designed for children in the ground floor [17]. The concept of ‘Flying Carpet’ is used to give an interesting touch, and this is the most attractive area beneath the curved field. The building is shaped in the form of a curved field in an abstract manner and supported by columns with irregular locations and directions, and it meets the existing structural guidelines.
3.3. Redesign of integrated waste management Park of UGM

Table 1 Key characteristics of various types of integrated park

| Precedent                    | Function                     | Concept                     | Zonation and Mass Management | Circulation | Morphology             | Building Uniqueness                          | Reference |
|------------------------------|------------------------------|-----------------------------|------------------------------|-------------|------------------------|----------------------------------------------|-----------|
| Sydhavns Recycling Centre    | Waste Management             | Attractive and Lively Urban Space | Based on Activities          | Linear      | Simple Form of Circle  | Building as part of Landscape                | [14]      |
| PIG City                     | Pig Farm                     | Experimental Farming        | Based on Needs               | Grid        | Vertical Orientation   | Building as system                           | [15]      |
| Super Market Sanya Lake Park | Super Market + Communal Space | Blind Super Market          | Based on Functions           | Mix         | Terracing Form         | Building as artificial landscape             | [16]      |
| De Wilde Plek                | Kindergarten                 | Flying Carpet               | Based on Functions           | Mix         | Form                   | Building components as attraction            | [17]      |
| PIAT UGM                     | Integrated waste management  | Shaft Garden                | Mix                          | Shaft Form  | Multifunction, edutainment, This paper |

The design concept of the Waste Management Park is as follows: (1) the need to make a sequence of spaces according to the level of activity, (2) the best shape to blend with the surrounding environment but still be interesting (different), and (3) consideration of exterior design to spark interests. A Waste Management Park integrated with livestock and agriculture must be used as a recreational education place (Table 1). For this reason, the concept proposed is a ‘Shaft Garden’; an experiment on the waste management area using the shaft that becomes the point of view of a building (Fig. 3). Shaft is a continuous channel connecting all the floors so that a utility pipeline can be installed. Shafts can be found in multi-storey buildings, either in houses or buildings. The garden refers to an area containing the components of hard and soft materials that support each other and are intentionally constructed by humans for relaxation.

Fig. 3 Layout and design of Integrated Waste Management Park UGM
The concept of ‘Shaft Garden’ makes the shaft a pleasant attraction for the visitors of the Waste Management Park by promoting the ‘Learning based on Experiences’ learning system. The concept transformation is practiced by creating visual attractions and spatial experiences from the management of bio-gas and compost [18] through (i) Ecorium that utilizes the shafts as shaft rotations, (ii) educational spaces that feature the shafts as a learning media, (iii) utilizing gravity as a utility distribution system, and (iv) creating a sequence of spaces according to function (Fig. 3). Integrated bio-cycle management and education for sustainable development (ESD) could stimulate sustainable economic, environment and socio-cultural aspect for sustainable environment and life [20,21].

4. Conclusions
The integrated organic waste management in the integrated bio-cycle system concept is carried out by developing a ‘Shaft Garden’ that combines the organic waste management from the agricultural and non-agricultural sectors. This concept is based on nature, natural norms, green, gravity, natural light, sun, mass flow, water flow, functional, diversified, multi-sector, multi-product, multi-functional, multi-use, edutainment, efficient, effective, attractive, economical, environmentally friendly, socio-cultural, energy cycle, organic, and low energy.

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