

Research Paper

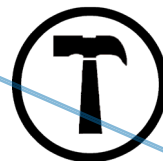
Circular Communities

For Housing

Transforming waste plastic and glass into building blocks making housing construction simpler, cheaper, faster and more sustainable



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Rushabh Chheda
4597281
rushabh.chheda@gmail.com
Mo Smit | Engbert Van Der Zaag | David Peck
Architectural Engineering
Faculty of Architecture, TU Delft

POTENTIAL OF MATERIAL CIRCULARITY IN LOW-COST KAMPUNG HOUSING

DECENTRALIZED UP-CYCLING OF WASTE TO PRODUCE BUILDING MATERIALS

Rushabh Chheda

Faculty of Architecture & the Built Environment, Delft University of Technology
Julianalaan 134, 2628BL Delft
rushabh.chheda@gmail.com

ABSTRACT

IN INDONESIA, THE POPULATION GROWTH, RURAL MIGRATION, IMPROPER WASTE MANAGEMENT SYSTEM, GOVERNMENT INEFFICIENCY, HAS LED TO ISSUES LIKE MASSIVE AFFORDABLE HOUSING SHORTAGE (± 11.4 MILLION IN 2015)¹⁸, ENVIRONMENTAL DEGRADATION AND POOR LIVING CONDITIONS. THE BUILT ENVIRONMENT ALSO IS RESPONSIBLE FOR ALMOST 60% OF THE TOTAL GLOBAL CO₂ EMISSIONS, THE PROBLEM OF HOUSING PROVISIONS THUS MUST INVOLVE USING SUSTAINABLE BUILDING METHODS. THIS RESEARCH PAPER PROPOSES A CIRCULAR USE OF MATERIALS TO SOLVE THESE PROBLEMS THROUGH A DECENTRALIZED SYSTEM. IN THIS RESEARCH, THE COMPOSITION AND QUANTITY OF WASTE AND ITS POTENTIAL AS A BUILDING MATERIAL IS EXPLORED, SO THAT THEY CAN BE APPLIED IN PLACE OF CONVENTIONAL BUILDING MATERIALS.

KEYWORDS: *Circular Economy, Sustainability, Upcycling, Housing, Affordability*

I. INTRODUCTION

In the context of Indonesia, waste management and housing provision are two big problems faced by the Government. Bandung, a city with a population of 2.57 million people, is expected to grow to 3.4 million by 2030. Currently, 40% of the total population belong to the low-income group.¹ Most of the municipal solid waste from the city is disposed by landfill, other methods being open burning, disposal in open areas and rivers etc., leading to hazardous environmental conditions. The heavy reliance of the peri-urban kampungs in Cigondewah on the textile factories for their income directly or indirectly, has made them very vulnerable. With the already active informal self-build industry and the informal waste recycling industry, there is a potential to provide economic resilience. The use of materials like brick, cement and steel, due to their high embedded energy, contribute to increased CO₂ emissions. The built environment is responsible for 36% of the global energy use and 39% of the total carbon emissions worldwide² and with the increasing demand for housing, if the current trend of using materials with high embodied energy continues is not controlled, the number is only going to increase. This will create problems for the country to acknowledge its goals for the Paris agreement, for which it has aimed to reduce its emissions by 41% until 2030 by reducing its reliance on natural resources, failing to do so will create negative consequences economically and environmentally.³

It's been a year since the Indonesian Government signed and committed to the Paris agreement, to curb their Green House emissions, to keep the temperature, rise below 2 degrees Celsius. Plastic, paper and fabric recycling form an important part of the local economy, along with the self-managed housing industry. During the recent visit to the site, a lot of data regarding the cost and time of construction, the income structure of people, the waste recycling industry was done, which provides us with valuable insights into the potential intervention solutions that can be implemented and the general acceptability of such solutions.

1.1. Existing Informal Economy

A major part of the population belongs to the low-income group. This problem along with the inefficiency of the government to provide sufficient low-cost housing has given grounds for some new economies to develop. These economies involve the self-build housing industry and informal recycling industry. The self-build housing industry developed from the need to provide, affordable low-cost housing to people who don't come under the umbrella of the existing government schemes. It involves a local or regional level of operation, involving contractors, material dealers and unskilled local labor, the absence of professionals like engineers and architects in the process, is evident in the quality of constructions undertaken.

The waste generated from households and various industries in the Peri-urban contexts, has caught the attention of some individuals who have managed to create an economy through reusing and recycling of such wastes. The existence of such a recycling economy, raises questions like the true potential value in resources lost to waste, which fail to get recovered. This paper tries to investigate these aspects of the local informal economy, which in the absence of Government aid, has managed to solve issues of housing provision and resource circularity and proposes a symbiosis of these economies, such that its benefits can be optimized and have a positive impact on the environment.

1.2. Design Research Question

Can we create a decentral circular material economy to solve the affordable housing deficit in the Kampung of Indonesia?

1.3. Circular Economy

A circular economy, aims to redefine the current take-make-dispose model of material use, with the aim to create long term societal and environmental benefits. It proposes a system, by taking out the concept of waste, keeping materials extracted from nature in use for as long as possible and regenerate the natural systems. It seeks to rebuild capital, may it be human, natural, social, financial or manufactured. The challenge arises in how to create a stable economy based on this strategy, such that it favors not only the capitalist ideologies of the society, but also the consumerist ideologies of individuals and all the actors working in and around it, directly reducing human environmental impact, while maintaining our current way of life. Change can only happen if every stakeholder benefits from it. The concept of circular economy is to consider how our waste can create capital rather than reducing it, by redesigning and rethinking the products and components of the system. With the advancements in modern technology and innovations, the transition to a circular economy has broader applications. The Ellen Macarthur foundation, is one of the leading organizations working for a circular economy, in their work, they outline the 3 principles of a circular economy.⁴

1. To preserve and enhance natural capital by controlling the finite stocks and balancing renewable resource flows.
2. Optimize resource yields by circulating products, components and materials in use at the highest utility always in both technical and biological cycles.
3. Foster system effectiveness by revealing and designing out negative externalities.

They have also identified certain building blocks essential for a circular economy. The first one, a circular product for its economic success must include, careful material selection, standardized components, longer life of products, ease of use and easy post-use sorting, separation or reuse of products and materials, and design for manufacturing.⁴ There is also a need for business solutions that either replace existing models or create new opportunities. An establishment with a profitable business model and circular ideologies will help inspire other people to use the same methods or apparatus elsewhere. The total worldwide economic benefit from waste and recycling was estimated to be at \$450 billion in 2010.⁵ A circular economy model is thus a very attractive and viable option as an alternative business strategy that has already started being explored by many organizations today.

II. INFORMAL SELF-BUILD INDUSTRY

The Government, although has successfully implemented many schemes for providing housing like the Kampung Improvement Program (KIP), the PERUMNAS program and the 1:3:6 policy, the national government invests only 1.5% of its entire budget on providing public housing, mostly invested in lower-middle class housing situations, the low-income housing situation remains unattended.⁶ In 2016, as per the government statistics, a total of just 6,354 housing units were provided under the PERUMNAS program in West Java, with an average per unit price estimated at 208 million IDR (13,800 euros approx.), growing from 760 houses in 2008 with 52 million IDR per unit price (3,500 euros approx.), indicating a 400% growth in the cost of each unit (BPS:2016). This results in a continued growth slum/ squatter population in the country, which is estimated to reach 27 million by 2020.⁷ The self-help or self-build housing system, is related strongly to the life in rural Kampung, where the ideology of 'Gotong-Royong' is still practiced, the term translates directly into communal work. The act of achieving a shared objective for the community with the help of several individuals, a system of community governance and cooperation. Thus, the residents depend mainly on their own efforts and their social networks for acquiring low-cost affordable housings. These urban kampungs are thus characterized not just by their informality, illegality and irregularity, but their resilience and flexibility as well. They provide a huge contribution for housing the urban low-income dwellers. Internationally as well, there has been a growing recognition about the role that informal housing settlements could play in providing solutions to the critical problem of affordable housing provision.

In Bandung, around 89% of the total housing stock are in the Kampung⁸, 70% of such constructions are done by the informal builders.⁹ As the low-income people don't have access to the formal schemes for housing, the self-build housing thus becomes the only alternative. These unskilled informal builders, due to the lack of technical skills, lead to poor structural quality of construction, leading to unsafe houses thus hampering the vertical expansion for densification and issues of land subsidence. With an increase in low-income population, there is a parallel increase in the density of these Kampung.

2.1. Housing Typologies

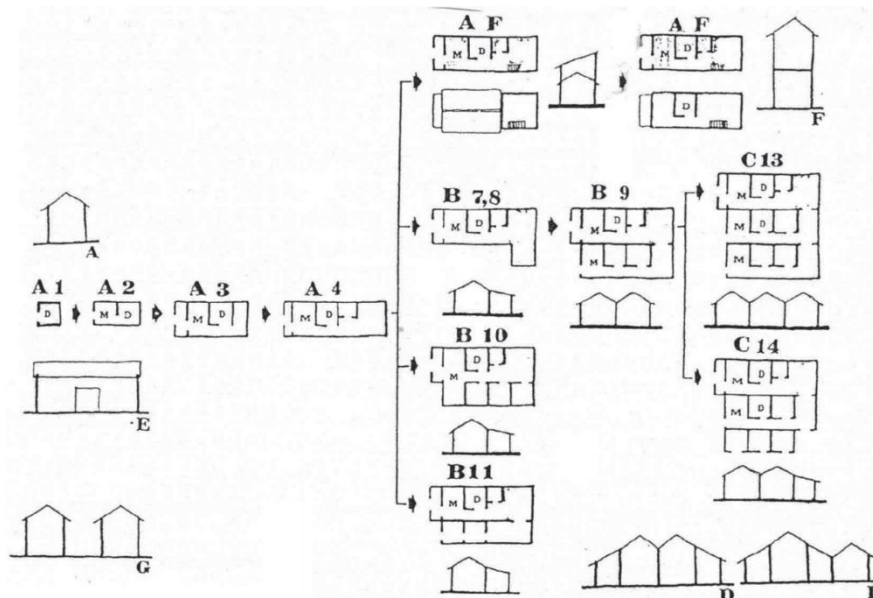


Figure 1. Incremental Kampung Housing Typologies

The kampungs have varied types of houses in different sizes from around 15 square meters to upwards of 200 square meters. Many similarities can be observed in the houses while doing field observations. A Kampung house is predominantly constructed incrementally, depending on factors like number of family members and their economic condition to afford for upgradation. The most basic

typology being a one- room unit, which has living room/kitchen and a bedroom, with a little open space in front of the house used for daily activities. The rooms are arranged in a sequence, with additional rooms added in continuation of the sequence. The house is upgraded horizontally first and once all the available space in the plot is used, it is expanded vertically to a maximum of one floor, due to poor structural quality of the house, higher constructions are expensive and due to the personal preference of the people to not construct higher. The houses are characterized by a narrow front width, with the gable end parallel to the access road and a longer depth. The Figure 1 shows the various types of house expansions found in a Kampung. Some houses also have rooms like, rental rooms for migrant workers, shops, small factory spaces etc., adding further variations in typology. A self-build can be also distinguished into 5 types based on the degree of participation of the dweller.

1. Traditional self-build house – where the dweller solely undertakes the construction
2. Commissioned self-build house – where the dweller owns and develops the house, but commissions the construction to a contractor
3. Aided self-build house – the state or an external body provides aid and the dweller is integrated in only the construction of the house
4. Assisted self-build house – the dweller is involved in the design and planning of the house and is provided with financial and technical assistance to construct
5. Organized self-build house – where a professional like an architect facilitates the planning and design process, also providing technical, financial assistance and the dweller constructs the house

The last two typologies, involve high level of participation of the owner and the community. It seeks to empower the community, helping to create a sense of self-sufficiency and provides stability for a continued development in the community after the assistance is withdrawn. In assisted and organized self-build housing, most of the control and responsibility in the process is with the dweller. As per the UN-Habitat (2005), this type of housing, promoting high community and individual participation helps them to acquire valuable skills and knowledge, that they can use as per their requirement and financial scope. “It is the most affordable and intelligent way of providing sustainable shelter. It is affordable because it’s based on minimum standards and incorporates a substantive amount of sweat equity.” (UN-Habitat 2005; 29)



Figure 2. A Typical Kampung House in Cigondawah



Figure 3. Material Transportation



Figure 4. Local Material Dealer

2.2. Construction system and materials used

Cigondewah, like many other peri-urban Kampung, used to be former rural settlements, which overtime got engulfed by the growing city boundaries. Kampung houses, traditionally built with renewable resources like bamboo, wood, stone, reeds etc. slowly started getting replaced by brick and concrete and other such materials which have a high embodied energy, completely changing the identities of these Kampung. The change in material use was also triggered by the people's perception of a house, they found the new constructions to be structurally safer, durable and low-maintenance. The new jobs that came with the textile factories, further discouraged the people from self-building. The dwellers make the design decisions and appoints a contractor and unskilled labor to manage the construction of it, a 'Commissioned Self-Build House'.

The Owner or the contractor, buys the materials from the local material shops, the Table 1. shows the different materials available at these shops and their prices. These materials are then transported to the site of construction, where with the help of local hired labor the house is constructed. The average cost of construction of a standard house in Indonesia is between 4.2 – 5.5 million IDR per m² (15,000 IDR = approx. 1 euro). The cost breakdown for the different construction phases for a low-mid size housing, constitutes of 37% structural (piling, foundation, and structure), 29% Architectural (walls, floors, ceilings and roofs), Mechanical and Electrical services 28%, and 6% for furniture and appliances.¹⁰ The cost of hired labor daily is, 103,000 IDR for unskilled labor and 115,000-120,000 IDR for a skilled labor.¹⁰

Description	Units	IDR '000	Description	Units	IDR '000
Excavating for footings : 1.5m deep	m ³	60	112.5mm thick brick walls	m ²	200
Removal of excavated material off site	m ³	25	0.64mm profiled steel sheeting	m ²	250
Hardcore bed binded with fine materials	m ³	400	Aluminum casement windows : single glazed	m ²	1,500
Mass concrete grade 30	m ³	1,000	Structural steelwork - beams, stanchions etc	kg	21
Reinforced concrete grade 30	m ³	980	20mm cement and sand (1:4) wall plaster	m ²	90
Coarse Aggregatge	m ³	250	Ceramic floor tiles	m ²	160
Steel rod reinforcement	kg	8.5	12 mm plasterboard ceiling lining	m ²	180
Sawn formwork to soffits of suspended slabs	m ²	190	Two coats of emulsion paint	m ²	25
Sawn formwork for columns and walls	m ²	170	Terracota ventilation blocks	1	20

Table 1. Cost of Construction Material Used

Often, due to unsafe constructions or legal problems like land titling issues, illegal encroachments, unsafe constructions and flooding problems, the government demolishes Kampung houses. The people lose their homes, and this sets them back economically, but they manage to build another such house again in another or the same location. The waste that is generated from this demolition goes into the already over exploited landfill. The Figure 5. explains the flow of this system.



Figure 5. Linear Flow of the Informal Self-Build Housing System

III. INFORMAL RECYCLING INDUSTRY

3.1. Municipal Waste Management System

Of all the problems resulting directly due to population explosion, one of the most prevalent is the improper Municipal Solid Waste Management. In Indonesia, as per a nationwide estimate, before 2005 an average of just 60-70% of the total MSW reached its final disposal site.⁸ The other 30-40% which is not handled by the government, either gets disposed by open burning, dumped in rivers and open areas. The scavengers only manage to extract a small part of the waste for money by selling the waste to recyclers. The flow and composition of the total MSW in Bandung is shown in Figure 6.

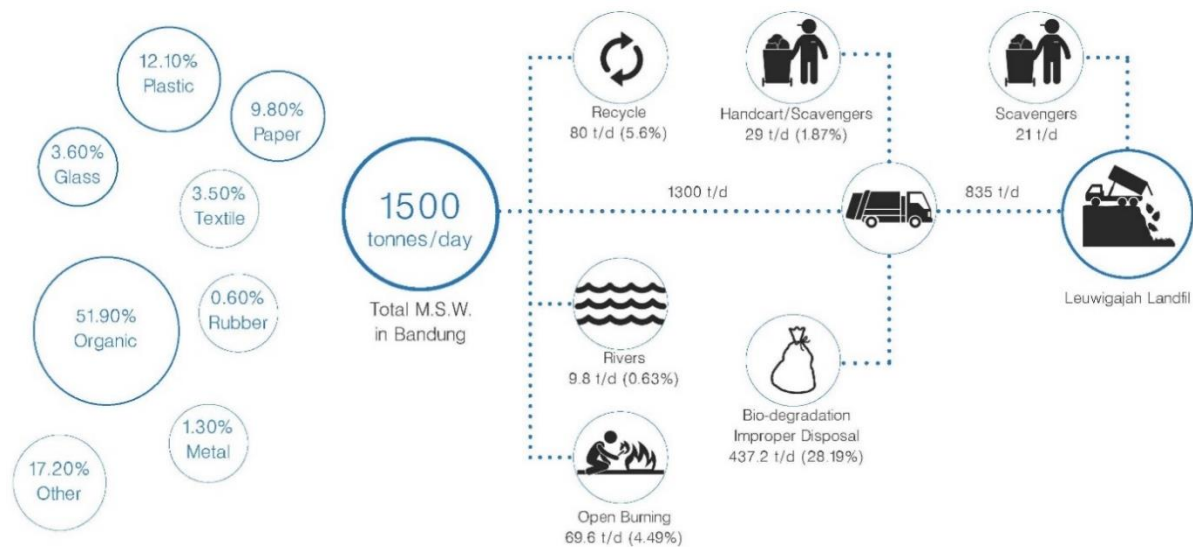


Figure 6. Composition and Flow of MSW in Bandung Metropolitan Area, t/d (tonnes/day)

The human society is a consumer society, to meet the needs of the society, a wide range of products are manufactured, and this creates more waste. This increase in the amount of waste, demands for more government investment to manage it and creates landfill problems. In Bandung, the system in place involves the municipality forming task-force groups in each sub district, relying mainly on manual labor and non-specialized trucks, these trucks carry the waste collected to transfer stations, from where it is transported the final disposal site.¹² This system fails to collect and properly dispose all the generated waste due to lack of monitoring, planning and evaluating. The waste collected by the city, is mostly sent to the Leuwigajah landfill for final disposal. This waste is not segregated, and contain recyclables like plastics, paper, textiles and other inorganic matter. In 2005 over dumping in landfills caused one of the worst disasters, and the second deadliest waste slide in history. The presence of textiles, plastics and paper, formed poor friction layers in the massive landfill, combined with heavy rainfall on 21st February 2005 lead to a disastrous waste slide, extending to an area of 300m X 900 m,

with a depth of average 10 meters. It affected 3 neighboring villages, burying 71 houses and killed 143 people.¹³ Thus, the problem of waste management needs to be tackled at every scale.

The city of Bandung, generates around 1500 tonnes of waste daily, 66% of which comes from households. After the landslide disaster, the total amount of waste collected by the city dropped to 40-50% from the previous 60-70%, meaning that a lot more waste ends up in the rivers and on the street.¹⁴

3.2. Recycling Industry



Figure 7. Junkman in Cigondewah



Figure 8. Waste Dealer in Cigondewah

The issue of the management of the MSW in Indonesia affects many aspects such as, environmental, social, institutional, technical and financial. Adopting a circular system of reducing, recycling and reusing becomes a valid solution to mitigate the problems. The government with its limited funding dedicated towards MSW management, has so far been inefficient in setting up the necessary infrastructure for recycling and reusing. The informal sector has been recycling waste since years, such activities are considered illegal in the country. These organizations are not registered and comprise of a low-level organization structure.¹² The informal recycling industry constitutes of mobile scavengers and junkmen, who collect waste from the households and the industries, and bring it to an intermediate collection point, where its sorted, this sorted waste is then sold to the local dealers, where it is further sorted based on the properties of the waste and from here, and later sold to a bigger dealer, the dealer either sells the waste for reuse or sells it to a recycler who processes the waste into a reusable raw material which can be used in production by a manufacturer. So there exists this, linear flow of materials, where the manufacturer is not liable to handle the materials that it sells to the consumers, creating a loss of resources at every level in the chain caused by the inefficiency of the waste management system (Figure 9). Due to their informality, they tend to evade government regulations, leading to unsafe working conditions, low wages and limited waste extraction.¹² The scavengers sell cardboard waste at 1,000 IDR/kg, textile waste at 10,000 IDR/kg and plastic waste at 7,000-8000 IDR/kg to the intermediates/dealers, the dealers further sell it to the recyclers or for reuse, cardboard big sheets for 3,000 IDR/kg and 2,000 IDR/kg, textiles at 15,000 IDR/kg for big pieces and 3,000 IDR/kg for smaller ones, plastic waste is sold at 10,000 IDR/kg. These figures were collected during the personal interviews of the dealers at Cigondewah. Mainly 3 types of plastic waste are collected by the scavengers and junkmen, LDPE, HDPE and PP.



Figure 9. Flow of the Informal Recycling System



Figure 10. Waste Plastic Dealer's Warehouse



Figure 11. Textile Waste Dealer

Only 10% of the total waste generated is recycled or composted, out of which, the informal sector manages to recycle less than 5% of the inorganic waste generated.¹⁴ It was also found that the low-income dwellers, segregate their waste at source, the sole motive of this being to sell it to recyclers for money and not to help the environment. As per a research done by Enri Damanhuri, from ITB Bandung, the informal sector manages to collect around 29tonnes/ day of inorganic waste. Most of the recycling industries have a very low capital to buy machinery and are usually run on a small or family business scale.

IV. CIRCULAR RESOURCE FLOW

5.1. Up-cycling & Prefabrication

Upcycling and recycling have different processes. Recycling by definition, means to return a materials value to a previous stage in the cycle, rather than disposal, moving it down the supply chain. Upcycling on the other hand involves the reuse of a discarded material in a way such that its creates a product with a value higher than the original use, moving it up the supply chain. Value of a material apart from its economic value involves, its purpose of use, the societal benefits, and its environmental benefits. A circular product design requires advanced skills, information sets and working methods.⁴ In the case of Cigondewah, this approach of up-cycling might help solve the housing problems, while creating jobs and development of the community. Recycling, prolongs the inevitability the product coming back in the waste stream, up-cycling has a broader approach, it is designed to not just reduce the amount of waste produced, but also reducing the need for virgin material to be produced or mined from the earth. Up-cycling in the building industry, could help reduce the extreme carbon emissions by the built environment.

Prefabrication of building materials and components helps to speed up the process of housing construction, as the onsite work is reduced to assembly. Also, a decentralized prefabrication facility helps to generate job opportunities for the community. Such a system of construction has been a part of Indonesian tradition for a long time, Kampung Naga is one such example, where prefabricated building elements using renewable materials like bamboo, wood, reeds etc. is practiced almost exclusively for all constructions. The entire community comes together to assemble the different elements into a house, strengthening internal organization skills. Prefabrication has the potential of empowering the unskilled labor as well, with easy building techniques and by implementing low-tech and local solutions for material acquisition and processing, the community can easily be integrated in the process. The precision of dimensions and better quality of the building components can be ensured due to the process. The waste that is produced during production can be put back into the process, thus ensuring circularity.

5.2. Conventional Building Materials

In Indonesia, in 2015 a total of 11,695,876 million IDR was spent on building materials and 164,827,265 million IDR was spent on fuel and electricity for constructions, the same figures in 2005 were 5,979,332 million IDR and 87,443,633 million IDR respectively, suggesting a little under 200%

growth in spending in the construction sector in a period of just 5 years.⁸ In Bandung, the average low-income housing construction has a material input intensity of 1.88 kg/m² (Table 3.), which translates to a total embedded energy of a house around 36.3 GJ (Gigajoules).⁸ The informal sector also performs the activity of reusing salvaged building materials into new informal constructions, bringing down the prices of construction considerably. Different construction materials have varying rates of reuse and recyclability, bricks up to 95%, wood has a recycling ratio of 38%, all the salvaged glass and steel can be recycled, 96% of concrete waste can be crushed and used in place of virgin aggregate, gypsum and plasterboards are 100% recyclable. Although, only 38% of the waste wood is recycled or reused, the rest of it can be used to generate energy, thus its energy saving potential is 100%, steel recycling helps save energy in mining new ore by 60%.⁸ If recycling and reusing of building materials is done to its full potential, it could help bring down the embedded energy of such homes from 36.3GJ to 22.6GJ, a reduction of 13.7GJ.⁸ The Table 2. shows the potential reuse, recyclability and energy saving potential of various salvaged building materials. Recycling of steel will help reduce the national trade deficit as 40% or 8.6 million tonnes of the total steel used is imported into the country as of 2011.¹⁵

Of the total households in the Kampung of Bandung, 61.5% have a monthly income of 100-500 USD (1.4mil-6.8mil IDR) and 4.5% under 100USD (1.4mil IDR). In addition, 42% of the smaller houses have had a life span of over 40 years⁸, suggesting that people often replace and repair the materials in their houses to extend its life.

Materials	Potential Rate %		
	Reusing	Recycling	Energy Savings
Mortar	0	100	0
Soil	100	0	0
Stone	100	0	0
Concrete	0	96	0
Clay Brick	5	90	0
Cement Brick	0	96	0
Steel	0	100	60
Ceramic Tiles	0	0	0
Clear Glass	100	100	5
Wood	50	38	100
Gypsum	0	100	10
Paint	0	0	0
Clay Roof Tiles	0	100	0
Concrete Roof	0	96	0
Asbestos Roof	0	100	0
Zinc Roof	5	90	96

Table 2. Potential Energy saving potential through Salvaged Building Materials

Materials	Density (kg/m ³)*	Current building material inventory			
		Simple	Medium	Luxurious	Whole
1. Stone	1,450	623.1	682.6	603.9	644.7
2. Clay brick	950	371.7	414.0	451.2	397.7
3. Concrete brick	2,300	7.5	0.0	0.0	3.6
4. Cement	1,506	118.8	185.0	227.2	157.6
5. Sand	1,400	561.0	674.4	740.2	626.8
6. Steel	7,750	17.3	37.7	34.0	27.4
7. Ceramic tile	2,500	15.5	34.2	77.4	30.0
8. Clear glass	2,579	1.2	1.3	6.2	1.8
9. Wood	705	143.1	161.5	43.2	139.2
10. Gypsum	1,100	0.3	1.3	24.4	3.4
11. Paint	700	1.6	4.4	12.4	4.0
12. Clay roof	2,300	20.7	30.2	0.0	22.2
13. Concrete roof	2,500	0.0	0.0	39.2	4.4
14. Asbestos roof	2,200	0.6	0.3	0.0	0.4
15. Zinc roof	3,330	0.8	0.1	0.0	0.4
Total		1,883.2	2,227.0	2,259.3	2,063.6

Table 3. Current Building Material Inventory of various types of houses in Bandung

5.3. Inorganic Waste as a Building Material

Plastic, paper and textiles, are the 3 types of waste collected by the informal industry in the Kampung. Of the total 465 tonnes of inorganic waste generated in Bandung daily, 181 tonnes is plastic waste, 147 tonnes paper and 52.5 tonnes textile.¹⁶ While most of the waste paper and textile collected by the scavengers in the Kampung in Cigondewah is reused directly by the industries, all the plastic collected is sold to recyclers to be broken down into virgin material only to be brought back into the waste stream within a short time-span after use.

Plastics pose a very big challenge environmentally if not disposed safely, Ellen MacArthur states that if we continue at the current rate of plastic pollution, there will be more plastic than fish in our oceans by 2050. The design project will aim at finding innovative applications primarily for plastics in the building industry, to extend its service to the user over a longer timeline, while also taking into consideration the end-of-life recyclability or safe disposal of the material. To convert plastic into prefabricated building materials, there are different processes and machines used. The first machine in the process is a shredder, which breaks the plastics down into smaller pieces to be used as raw material. The next process involves melting and making the product using different techniques like, compression,

injection and extrusion. Compression involves melting the plastic in a mold and applying high compressive strength to it to achieve the desired shape, injection involves injecting the melted plastic into any desired mold, and extrusion is used to create continuous profiles such as pipes and window frames. Further research during the designing phase, will help to decide which method is best suited for the project.

One organization, working to make building components using plastic waste is Bogota based 'Conceptos Plasticos', founded in 2010 by Architect Oscar Mendez. Different types of plastics collected by the informal collectors are broken down in a crusher separately and then melted together in an optimized ratio along with additives for fire resistance, at a temperature of around 200-240 degrees Celsius to create 8 different upcycled products using the process of plastic injection. These products include Lego-like bricks of different sizes, beams, columns and window frames. It costs 6,400 USD (excluding transportation costs) to make a house of 40 square meters using these components, which can be constructed in under 5 days and can be dismantled in 3 days in the case of forced displacement. Such a house can consume up to 5 tonnes of plastic, the same amount of plastic would fill a 12m container. The house reduced the cost of housing construction up to 20% in rural Colombia. Currently they recycle 90 tonnes of plastic monthly, enough to build 15 houses each month. The organization is funded by NGOs, local business groups, foundations or the public sector, to increase affordability for the dweller.¹⁷

Around 36 of such houses can be constructed daily in Bandung, if all the plastic waste is upcycled.



Figure 12 (left) and 13(right). Prefabricated Plastic Building Components by 'Conceptos Plasticos'

One of the problems might arise for the successful application of such a building material is its social acceptability factor. The people living in the Kampung switched to the use of brick, cement and steel as building materials, due to its durability, protection, privacy, sound insulation, resistance against insects and its flexibility for visual expression. So, in the interviews conducted, the question asked to the people was, would they use such a material for their houses that is made from their own waste? The feedback they gave was, if the new material provides the same characteristics that the current materials do and if it is cheaper, then they would have no problem in using it. But, to prove the applicability of the material, they would first want to see it function in a prototype, only when the results are tangible, the people can trust the system.

5.4. Role of the Architect

The role of the architect needs to be reinvented and carefully integrated in the process to integrate the different members of the community. The organization of the system, aims at empowering the community by promoting local participation in the process, a bottom up approach. The architect can provide his technical assistance, conduct workshops for the residents, design prototypes, take part in the development of a business plan, include the people as co-designers and thus embrace social responsibility. Architects can act as facilitators in the process of creating a circular material economy,

to solve the issues at hand. They don't take the primary position in the process, but act as contributors with the aim of bringing the costs down, increasing sustainability and speeding the process of housing provision, to improve the living conditions and the natural environment.

The architect helps to make design solutions more accessible to people who couldn't afford or didn't feel the need for a professional intervention. Self-build housing is a very democratic way of construction, to continue this process, an architect must be willing to take a step back from the central position he enjoys while designing, to give away with their authority and give major responsibility to the community. Such a system works rather efficiently in the absence of any intermediary bodies between the people and the architect. The government with its bigger agenda being not to earn a profit, but the overall development of the state, might be an investing partner.

VIII. CONCLUSION

In Cigondewah, Indonesia, like in many of the Peri-Urban Kampung, the existing informal industry can be organized to form a decentral network for the collection, processing, reusing and upcycling of salvaged building materials and domestic inorganic waste. The design approach to follow this research paper aims at using these circular concepts of upcycling of domestic waste by creating prefabricated building elements and using salvaged building materials back into housing construction as some of the construction will still need to be done using conventional materials, which could help reduce the total cost and time of construction, the use of materials with high embedded energy and the amount of waste being disposed into the environment. This will thus curb the amount of carbon emissions caused by the built environment. It aims at developing on the existing structure of the informal industry for co-operation and organization.¹⁸ The Government can provide for policies that support these activities and provide for financial aid. The long-term benefits of such a system can prove to be highly beneficial for the Government, they could provide for educational workshops and training of these communities, the communities can acquire technical skills, better and safer living conditions and create economic opportunities for them, reducing their dependence on the external institutions and organizations like the textile factories to provide for their economic and social needs. This design approach, works towards 10 of the 17 sustainable development goals listed by the United Nations Development Programme. (Figure 14.) These new networks of co-operation between the community, the government and professionals like architects, will speed up the transition into a circular economy.



Figure 14. The UNDP development goals tackled by the design proposal

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