ECSEE2019 & INDEPENDENCE & INTERDEPENDENCE

Official Conference Proceedings

ISSN:2188-1146

Organised by The International Academic Forum (IAFOR) in association with the IAFOR Research Centre at Osaka University and IAFOR's Global University Partners

JULY 09–10, 2019 | BRIGHTON, UK

"To Open Minds, To Educate Intelligence, To Inform Decisions"

The International Academic Forum provides new perspectives to the thought-leaders and decision-makers of today and tomorrow by offering constructive environments for dialogue and interchange at the intersections of nation, culture, and discipline. Headquartered in Nagoya, Japan, and registered as a Non-Profit Organization (一般社団法人) , IAFOR is an independent think tank committed to the deeper understanding of contemporary geo-political transformation, particularly in the Asia Pacific Region.

INTERNATIONAL

INTERCULTURAL

INTERDISCIPLINARY

iafor

The Executive Council of the International Advisory Board

The European Conference on Sustainability, Energy and the Environment 2019

Official Conference Proceedings

ISSN: 2188-1146

The International Academic Forum (IAFOR)
Sakae 1-16-26-201
Naka Ward, Nagoya, Aichi
Japan 460-0008
ww.iafor.org

Table of Contents

The Future of Dwelling: Redefining Dwelling for the Anthropocene

Camilo Cerro, American University of Sharjah, United Arab Emirates

The European Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
Between 1970 and 2015, the average size of newly constructed homes in the United States, increased by 79%, from a size of 1,660 square feet (154 sqm) to 2,687 square feet (250 sqm). This shift has redefined our conception of the family unit and inherently, it has also redefined their habitation needs. With an estimated third of households in the United States, spending more than 30% of their income on housing, it is time for housing design to move in a different direction. It is the time for a housing revolution, designed to reassess the real habitational needs of the user to provide a better quality of life designed for the needs of the next decade. The future of dwelling requires homes that can coexist and live in symbiosis with their environment, develop mechanisms for human interaction and socialization, help the household financially by making the dwelling more self-sufficient and use technology and space planning to resize the space needed for dwelling in search for a typology designed for the purpose of right-sizing human inhabitation. These housing typologies will need to be versatile and adaptable, to accommodate the needs of all types of family unites and the transformations they suffer as they evolve in their spaces for living. In this paper, I will showcase work done to develop a live/work/farm inhabitation typology in search for proposals to start defining the future of dwelling.

Keywords: Habitation, self-sufficient, right-sizing, adaptable, live/work/farm

iafor
The International Academic Forum
www.iafor.org

Introduction

It comes as no surprise that the average house has grown in size and cost over the last six decades, but have they changed much? In the 1950's, the average home was 1,232 square feet (114 sqm) [1], growing to an average size of 2,687 square feet (250 sqm) by 2017. But the space planning of a house has remained the same. In a world where social, financial and ecological structures seem increasingly tenuous, emerging technologies together with a diverse understanding on what constitutes a modern family unit are starting to reshape our design approach towards residential architecture. The idea of the traditional nuclear family has given way to multiple types of non-traditional family unions and living arrangements that are forcing residential design into a much more adaptable typological complexity. Adding to this, it is estimated that by 2020, 50% of the labor force of the developed world will be self-employed, turning their residences into micro-factories where they will make, package and sell products with the help of the internet and online marketplaces. In this new economy, the idea of the industrial zone in urban areas, which is a legacy of the twentieth century, will slowly be taken over by live-work residential design. In a similar way, the next generation habitat will be forced to reclaim certain elements of farming and resettle them in the city. Produce will be grown in house through hydroponics or other high-tech irrigation systems designed to help the household cope with the cost of living. All these technologies; mushroom production, grey water filtration systems, solar and wind energy, composting, and other passive and active advances will be dependent on affordability which will push residential design more and more into the realm of prefabrication to cheapen costs. As the future of dwelling is idealized, it presents an opportunity to reinvent residential living. This new design typology will need to get to a point, where sustainability is habitual to production, forcing smart technologies to be embedded in a systemic way through modularity and interchangeability in the new construction processes. These new dwellings will use an open plan approach as a way to create versatility. The resultant systemic interdependence will be the basis for the creation of the next generation of prefabricated habitation typologies which will be designed for transformational adaptability, production and filtration of water, generation of energy, urban farming and the capacity to sustain a live/work/farm environment in an affordable way that appeals to the middle class. Right-sizing will be an essential aspect of this process, as it develops dwellings designed to be versatile, adjustable, and user friendly. A housing typology re-designed for functional living, remote working and urban farming in a sustainable self-sufficient way will define the future of dwelling for the Anthropocene.

A brief history of dwelling sizes in the United States

In the 1950's a 1,232 square feet house would cost around $8,545.00 dollars (figure 1). This house would be composed of; three bedrooms, a kitchen, a living room, a dining room and a garage. The adjusted value of this house for 2015 dollars would be around $44,600. And although it's natural for prices to rise over time, the issue here is that home values are outpacing inflation, making it nearly impossible for new and young buyers to enter the market. This partially happened because the size of a house has changed in two opposing manners: According to the US Census Bureau [2], the average house built in the US increased from 1,660 square feet (154 sqm) in 1973 (earliest available housing-size information from the census) to 2,687 square feet (250

sqm) in 2015. This is an increase of 1,000 square feet (92 sqm). During the same period of time, the average household size has decreased from 3.01 to 2.54 persons per household, a reduction of one-half person per household. With the average number of people per household declining, the percentage of households of people living alone has climbed dramatically. In the past 6 decades, the percent of households of people living alone has risen from less than 10% in 1940's to 25% in 2000's. Even as the number of people per household has been declining, houses are still growing in size. This means these houses have more bedrooms and bathrooms. The percent of housing units with 1 and 2 bedrooms have been steadily declining, while the percent with 3 and 4 bedrooms has been increasing. The number of bathrooms shows a similar trend. Housing units with a single bathroom have declined from being almost half of new construction in 1973, to a little over 10% as of 2001. During the same period, the number of housing units with 2 or more bathrooms has climbed to over 80% of all new construction. This trend has ended up with more expensive houses which are partly why the typical homebuyer today is 44, whereas in 1981, the typical homebuyer was 25 to 34. In 2016, home prices rose twice as fast as the national inflation. And in nearly two-thirds of the country (USA), housing price growth exceeded wage growth.

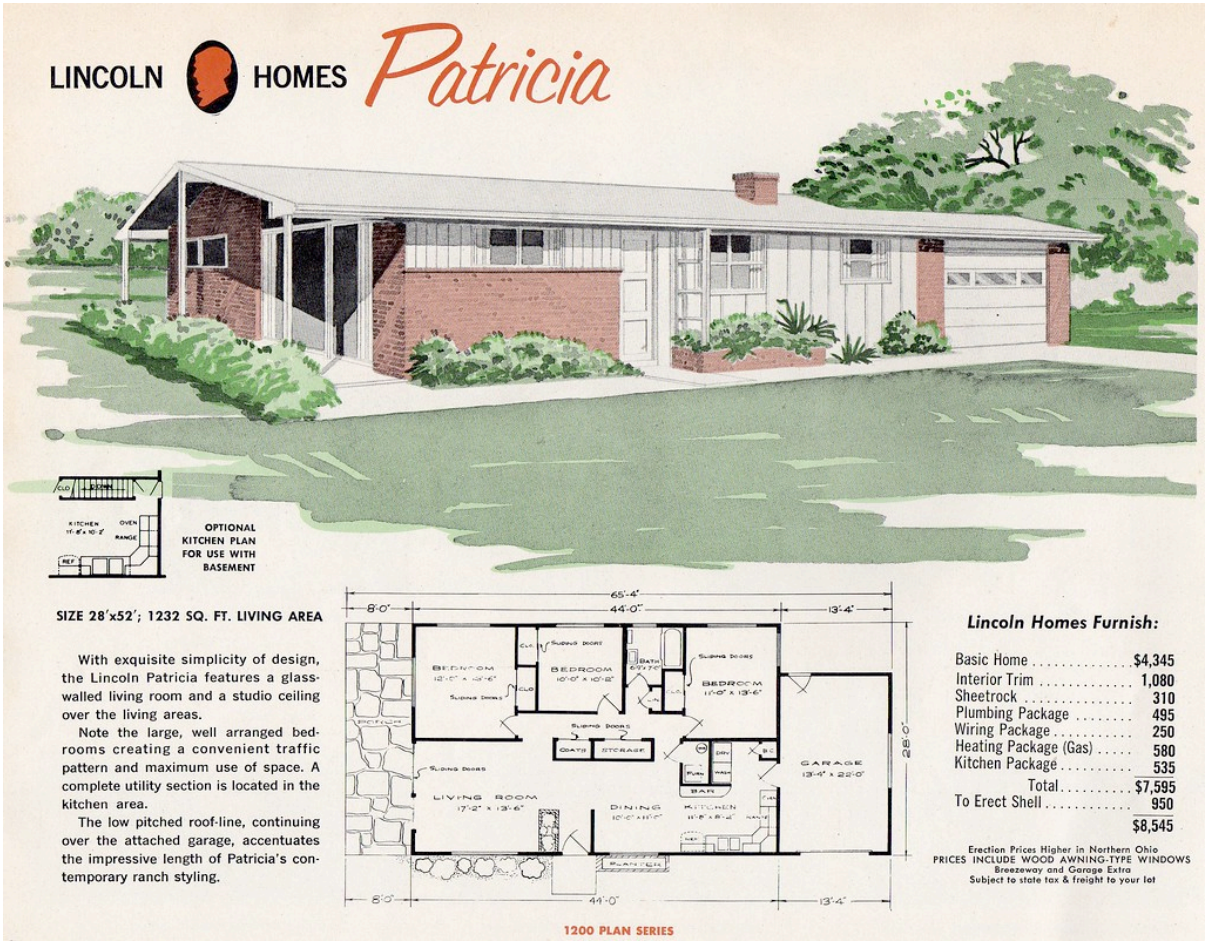

Figure 1: Lincoln Home-Patricia, 1950's

Is bigger better?

The reality is that bigger is not better. Because, better is better! And let's be clear, I am not talking about tiny homes. Right-sizing means not as big as you thought you

needed, but designed and built to suit the users long term way of life. But how are smaller homes better:

•*Easier maintenance and less time cleaning:* Anyone who has owned a house knows the amount of time, energy, and effort it takes to maintain it. Fewer rooms means less time spent on cleaning and fixing things. A large house encourages you to have more "stuff" in it, which is more "stuff" that needs to be cleaned and cared for. All things being equal, a smaller house requires less of your time, energy, and effort to accomplish that task.

•*Money savings and less debt:* Because a smaller home typically costs less, this frees up money every month to spend on other things. It's not just the lower mortgage payment that will save you money. Smaller homes are less expensive to purchase and less expensive to maintain (insurance, taxes, heating, cooling, electricity, etc.). That adds up to major savings over the years. Another aspect of savings we need to talk about are taxes. Our property taxes are determined by assessed property value, and value is partly determined by square footage. Though a number of other important factors also affect assessed value, all things being equal, smaller homes equal cheaper property taxes.

•*Freedom from stress:* Just as important as the monthly savings, is knowing that you're living below your means. This gives you peace of mind if you have a major financial setback like being unable to work, losing a job, or having a serious medical problem. A small house also encourages you to get outside more often.

•*Freedom of time:* Along with buying less stuff because you have no room for it, you will also avoid the time costs of maintaining all that stuff, as well as the time cost of keeping your large house clean and well maintained. Living in a small house means that the needs for your home will require less of your free time, allowing you to have free time for other activities.

•*Closer family and neighborly bonds:* Unlike the often gigantic rooms of a McMansion, small homes have small rooms. This gives each room, as well as the entire house, a feeling of coziness and intimacy that larger homes lack. In turn, this forces family interaction, not allowing it's members to hide from each other ensuring social interaction. When you live in a small space together, you learn to work around each other and diffuse problems before they happen. That is internally, but externally a small house forces you to be more extrospective putting you in touch with your neighbors and community. Small houses are often set closer together. Spend an afternoon sitting on your porch, and you'll have the chance to see your neighbors children playing on the sidewalk, people doing yard work, and the walking their dogs.

•*More energy efficiency:* Smaller homes are often more energy efficient because they have less space to heat and cool, which means they have a lower ecological footprint. They also use less materials in the building process. But in addition to these environmental benefits, small houses are also generally built in more walkable areas, which means you don't need your car every time you need to run an errand.

•*A small house is easier to customize:* A large house can be very expensive to furnish. When you live in a smaller house though, having your space set up and decorated

exactly how you want it is pretty easy! Space limitations challenge our creativity and drive innovation. Also small living changes how you view making new purchases. In a large house, there's always room for more, which adds to our consumeristic mentality.

•*Easier resell value:* By its very definition, a smaller, less expensive house is affordable to a larger percentage of the population.

An American home built in the last three decades, is forcing us to pay all the time for a lot of space that we only use some time. And while a big home may still be a dream for some, a smaller home may be a smarter and more flexible choice for those who want to save money, energy, time, and relationships.

What is Right-sizing?

As McMansions start to become a thing of the past, the National Home Builders Association stated that, the average size of a new home was expected to shrink to 2,575 square feet by 2019. Post-recession home buyers are seeking practical and functional space over surplus square footage. Right-sizing then is a design approach that uses emerging technologies, combined with research on the future needs of residential living and environmental changes due to global warming to propose sustainable dwelling designs for the up and coming future. It proposes homes that can coexist and live in symbiosis with their environment, develop mechanisms for human interaction and socialization, help the household financially by generating passive income and use technology and space planning to resize the space needed for dwelling. Finding the right home size for the user's needs will be an essential aspect of this process, as we develop dwelling units designed to be versatile, adjustable, and user friendly to accommodate to the needs of all types of non-traditional and traditional family units and the transformations they suffer as they evolve in their spaces for living. A process aimed at producing a housing typology re-designed for functional living, remote working and urban farming while providing dwelling solutions that allow for smart growth, shaping the way urban density will manifest in the future.

Smart house technologies in systemic interdependence

Systemic interdependence requires that both active and passive technologies work together to make in this case the house more self-sufficient and sustainable. The goal is to go past designing a green building and move both the design and build process to result in a net positive dwelling. An important part of that process has to do with how emerging technologies are being used interdependently to achieve our goals. In this section, I will cover some of this technologies and how they function:

•*Energy:* When talking about energy in residential living, I am normally thinking of it in two ways: Sustainability and the potential for self-sufficiency. In all our projects this quest starts with solar panels or tiles on the roof of the structure. This roof will be designed to a pitch that works well both in the summer and winter. The solar panels will be maximized to produce the required amount of energy which will be stored in a Tesla battery (solar battery) which will be stored on an equipment closet somewhere within the dwelling. The energy stored will be used in appliances, the working of the

different systems and illumination. To save on energy during the day, illumination of the residence will be aided by the use of solar tubes where possible. This system can be over designed in places where the government buys your extra energy creating a source of passive income. Which is a financial incentive and one way of making your house net positive. Solar heaters on top of the house will provide warm and hot water as needed.

•Water: The water systems are divided into active and passive. The passive ones comprise; water catchment systems and storage tanks while the active ones have the potential to make the dwelling water self-sufficient. It all starts with atmospheric water generators, turning the moisture in the atmosphere into drinkable water. This water is used for showers, toilets, drinking and farming. The grey water produced in these processes is filtered and sent to a tank for storage and reuse while the black water goes into the sewage. At this point we can change the toilets from water based to composting and not need water at all. This option will be covered further down on this section. The water can be held on tanks under the house until needed, when solar pumps would then bring the water up into the residence.

•Food production: The kitchen is provided with a couple of farming technologies. Drawers with mushroom farms will produce year around. Also in the kitchen, hydroponic vertical farms will produce a portion of the produce for the dwelling. These systems together with seasonal farming on the exterior garden and terraces will provide the family with fresh produce reducing their food cost. Any excess on the food production can be sold within community markets in the neighborhood.

•Composting: This process starts in the kitchen also, where worms will eat all the organic waste and produce liquid and solid compost to be used in the seasonal exterior farms. To achieve full plumbing self-sufficiency, the possibility of using composting toilets would remove the need for the dwelling to be dependent on the city sewage system. The human compost should not be used on the external farm but can be used in none edible gardens.

•Prefabrication: Prefabricated construction is the practice of assembling a variety of components of a structure at a manufacturing site and transporting those sub-assemblies to the location of the construction site. Since prefabricated sub-assemblies are constructed in a factory, unused materials can be recycled or re-used in-house. Also, the controlled environment of a factory allows for a more accurate construction, tighter joints and better air filtration, which in turn allows for better wall insulation and an increase in energy efficiency. The modules are commonly delivered by a flatbed truck to the construction site. Once there, cranes and trucks are used to assemble them in place. The foundation is the only aspect of the build that is done on site.

Net positive design: Creating regenerative buildings

Regenerative-design buildings go beyond typical green construction by seeking to achieve a net-positive impact on both the environment and the quality of life for its users. Architects take a systemic interdependent approach that considers; materials, cyclical systems, health, and building inhabitant usage. Net-positive performance can be achieved by spilling over to the community, the benefits derived from regenerative

buildings, which may, for example, sequester more carbon than is emitted by the production, transportation, and installation of building materials; self-produce energy instead of taking it from the grid; generate, catch, store and purify all potable water and treat, compost and recycle all grey and black water; operate carbon-free; produce a percentage of the produce consumed by the dwelling; and include interiors that improve human mental and physical health, deliver day-lighting and natural ventilation, and provide flexibility and adaptability of use with transformative potential looking to the future.

Methodology

The act of designing in architecture is complicated. Because a lot of it is intuitive, some people tend to think that it is not a well-structured process. But intuition which grows from research and experience is not only easily structured but also quantifiable. With that in mind, I developed the following methodology:

•We started by looking at statistics from the American time use survey provided by the Bureau of labor [3].
•We looked at the work presented by a UCLA team on the book Life at Home in the Twenty-First Century: 32 Families Open Their Doors [4].
•An analysis of architectural precedent composed of residential design measuring between 400 square feet and 2000 square feet was stablished to provide case studies for the different interior and exterior elements of the dwelling. From this analysis a prototype kitchen was produced which won the research and development award at the Reinventing Home Kitchen Design Competition, by Mia Cucina and Archiparti in Hong Kong, China.
•An analysis of type was produced to generate through it a design methodology.
•A design process was stablished with the aim to produce five distinct prototypes to address the live/work/farm typology.
•Designed a construction system to be prefabricated and easily installed in site.
•Researched new construction materials suitable for the project, assessing; Cost effectiveness, sustainability, carbon footprint, local availability and close loop potential.
•Researched different sustainable technologies to design the smart systems of the dwelling. This included: Hydroponics, aquaponics, mushroom farming, composting, energy production and storage, grey water filtering and reuse, water production through atmospheric water generators and sustainable thermal insulation.
•Presented a project based on this research for a dwelling competition sponsored by eleven magazine where we won an honorary mention.
•Designed a proposal for the inner city that uses the research on right-sizing to develop a town house to address the question of density.

The biggest problem we are anticipating is being able to produce a product that is versatile enough for different possible users. To address this issue, we are working with modularity and open plans. The modularity will allow us to resize the house cheaply and the open plan will give the user a level of adaptability and control of their interior space. All proposed prototypes will then be able to right-size to the needed footprint. Growing vertically will allow us to deal with density were we are looking in triplicating the present population of a specific urban block.

Design proposals

The following designs were produced and developed over the course of the last six years, and have been written and presented extensively.

•*Micro-houses:* The micro-houses (figure 2) are adaptable extrusions designed to assume the size needed by the user. The single extrusion allows for the space to grow in two directions, increasing the size of both interior and exterior-covered space as needed. In the interior, the long sides of the volume get built-in furniture, designed to maximize functions and storage. Within this built-in elements, we house; shower, toilet, closet space, kitchen, pantry, open shelves, drawers, a murphy bed and storage cabinets. The exterior has two terraces which add covered space to the interior by being accessible through two accordion glass doors at each short end of the volume. When the weather allows it, the accordion doors can be left open to enlarge the interior space, and when not the visual link to that exterior space remains through the glass doors. Inside, the kitchen pierces through the wall with a window that mirrors itself on the wall behind it creating a built-in dining area that uses the extruded window as a sitting area. The roof is accessible and meant to be used as a seasonal garden and leisure space. The house uses all the technologies previously mentioned to function as a smart house. And it is prefabricated and brought to the site as a whole, to be placed on top of the structure. The structure is the only element built on site, and it is composed of a spider footing system, designed to adapt to different topographies and to interact in a minimal way with its environment. This house has been designed for one or two occupants, but can be expanded for more if needed. Following the same parameters, we have designed five micro-houses of which another example of a dwelling for four people has been added below (figure 3). This houses have been designed to stand on its lots, whether in the city or suburbia, allowing for the maximum possible green space around the house. The idea is to use greenery to create privacy and to give space for urban farming to occur. Later on, when we talk about density, we will touch on the idea that by greenifying the blocks we are contributing also to better air quality for the community. In this way the lot and the dwelling work in symbiosis adding to the quality of life of the individual and the neighborhood simultaneously.

Figure 2: 350sqft [32sqm] of enclosed space 518sqft [48sqm] of open terrace

Figure 3: 600sqft [55sqm] of enclosed space 160sqft [14sqm] of open terrace

•*Trailer home redesign:* The trailer home is a housing typology prevalent in the United States due to its adaptability and low cost. With this in mind we have designed an upgrade to this classic (figure 4) where prefabrication allows us to produce the dwelling in sections, all of each housing a different function. The user, then can choose from the different functional modules to put together the house she/he needs. Each of the specific modules can then be designed in different styles to give the user options and to allow for diversity within the interiors. The modules have been designed to fit together allowing for compositional freedom longitudinally. There are multiple profiles designed for the base extrusion to give the used a variety of house front elevations to choose from. Some of them, adding a terrace above the house. Just like the micro-homes presented before, this proposal uses all the smart technologies covered on this paper and similar design ideas to add quality of life to the dwelling in a sustainable way. The modular prefabrication allowed us to explore a different type of adaptability and versatility for the dwelling, following right-sizing ideas. This project won an honorary mention in the Eleven Magazine, micro-living revolution competition in 2018.

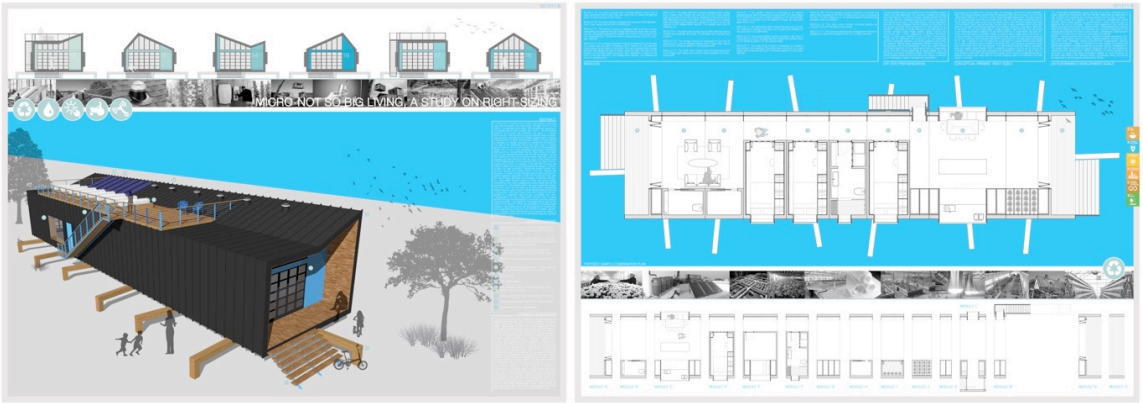

Figure 4: Eleven Magazine: Micro-Living Revolution Competition | Winner of an honorable mention

•*Low-income housing:* On this project, the same parameters are followed but in a system that is starting to consider density. To lessen building cost, this proposal uses shipping containers. The first floor uses 20’ containers to generate a commercial zone, followed by 40’ containers on the second, third and fourth floor. The containers are

set, side to side, generating a 745 square feet floor plan, with a central core for an open kitchen, bathroom and storage, and two pop out volumes on the back, housing the bedrooms. Each apartment has been designed for four to five people. The fifth floor is designed to be an urban farm, to be cared and maintained by the occupants of the building.

Figure 5: 745sqft [70sqm] of enclosed space 85sqft [7.9sqm] of open terrace

The center of the block has been designed as a public green area for pedestrian traffic. This park, is flanked at the two longitudinal sides of the block by buildings, that have their commercial level open to the inner and outer sidewalk, creating a directional continuity and permeability through the ground level. This openness adds a level safety to the area, since you are being watched all the time by someone. At the urban level, the urban farm at the top of the building and the park/garden at the ground level are adding a green component to the city capable of purifying the air and generating local grown produce. All the previously presented technologies and design ideas are also part of this project.

•*Micro-apartments:* Similarly to the last project, the micro-apartment is a building composed of a built on site structure, designed to receive prefabricated units. This units are height ceiling lofted spaces that follow the same parameters of the micro-houses presented before. The units are designed to house one or two people. Also like a previous project, the building has a commercial space on the first floor and residential above. And just like the last project, this proposal is looking into ideas that deal with density but trying to preserve the quality of life of the future user. This balance is, I believe, the basis for a successful urban strategy for the future of cities.

The goal of this research is to identify; emerging technologies, construction techniques, human social tendencies and smart design, that can allow us to re-size our residential requirements and change human habits to better our quality of life and lessen our foot print in the planet.

Density: Smart city

Urban density refers to the number of people living in a particular urban area and is an important aspect of how cities function. The response of a neighborhood to its density in terms of accessible services is what makes a city successful. A good neighborhood should serve all its population's needs within the neighborhood itself, preferably at a walking distance of your home. However, when cities are allowed to expand from the center out without the benefit of smart growth planning, they can become relatively unsustainable. Cities operate more efficiently when residents live in denser urban surroundings, with services at a walking distance and good public transportation. And an efficient city is more sustainable. Through this paper we have concentrated on right-sizing but I want to end with some ideas in terms of urban density, because these two ideas work side by side. So once the right-size of a dwelling gets resolved, we need to think about the block and the neighborhood around it. Following are some ideas that have informed our density based proposals. The following are the urban ideas we are working with while designing our projects that can help turn high-density city into a smart city:

•Plan for long-term growth and renewal.
•Embrace diversity and foster inclusiveness.
•Greenify the neighborhoods, starting with the dwelling itself.
•Develop affordable, mixed-use self-contained neighborhoods.
•Activate public spaces.
•Prioritize green systems.
•Visual overlap (eyes on the street) adds a sense of safety and security.
•Forge public-private partnerships.

Conclusion

The aim of these projects is to develop a new typology of residential design that re-educates the population towards a more affordable, sustainable and energy efficient future. From the beginning, the project has attempted to increase the quality of life of its inhabitants. To do so we have stablished an interdependent series of system designed to help the dweller by:

•Producing in-house some percentage of their food necessities in a healthy, organic and fresh way.
•Producing their own electric power and using natural light to minimize energy consumption.
•Cleaning and storing, rain and grey water for future use and re-use.
•Defining the appropriate size of the dwelling in terms of its users.
•Providing an affordable alternative to the housing market by the use of prefabrication and the minimizing of dwelling's area.
•Creating versatile spaces that allow for personal adaptability.
•Providing spaces for the development of self-employment.
•Creating community by breaking the trend of the introspective residence and forcing the dweller to re-engage with his neighborhood.
•End the life-long slavery to the mortgage by creating an affordable home.

The next step is to implement this ideas on our next residential project, which (it seems) will take place in 2020 in Woodstock, New York.

Acknowledgments

This research was supported by the American University of Sharjah and the College of Architecture, Art and Design. And the Open Conference on Sustainability, Energy & the environment for accepting my presentation and paper.

References

[1] Sparshott, J., US *Houses Are Still Getting Bigger*, The Wall Street Journal, June 2nd, 2016.

[2] US Census Bureau (2015, June 10th), *Characteristics of new housing*, retrieved from: https://www.census.gov/construction/chars/highlights.html

[3] Bureau of Labor Satatistics, 2017, *American time usage survey*, bls.gov. Available at: https://www.bls.gov/tus/charts.htm [Accessed, October 2017].

[4] Arnold, J., Graesch, A., Ragazzini, E., Ochs, E., 2012, *Life at Home in the Twenty-First Century: 32 Families Open Their Doors*, 1st ed. USA: The Cotsen Institute of Archaeology Press.

Contact email: ccerro@aus.edu

The Quality in the Separation of Rigid Packaging of High-density Polyethylene – Application to a Real Case in Portugal

José Miguel Aragão Celestino Soares, Universidade de Lisboa, Portugal
Fernanda Maria de Almeida Santos Mendes, Laureate International Universities, Portugal
Ricardo Simões Santos, University of Aveiro, Portugal

The European Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
In recent years, companies producing high-density polyethylene have been affected by huge reductions in sales volumes as well as the value of these same sales.
The PFAU-PMP collects and treats different types of plastics that, due to their physic-chemical characteristics, can be recycled, valued, and subsequently reintegrated into the value chain (for example, high and low density polyethylene, polypropylene and polycarbonate). PFAU's Portuguese office had the necessity to improve the quality of 4000 tons of high-density polyethylene, currently packaged in bales. To do it the company felt the need to proceed with a correct sorting solution, taking into account that the Portuguese recycler involved in this project (for reasons of confidentiality will be called Company ABC) has some legal obligations with product treatment, and also that some value must be added to the final product. The objectives of this research are to study how to proceed to the correct separation of the packages, through product quality criteria, and to define which of the processes, mechanical or chemical, is the most correct for the treatment of 4000 tons of polyethylene. Based on this study, it is concluded that it is possible to improve the quality of the final product by introducing a pre-automatic manual sorting carpet, allowing correct color separation, removal of contaminants and identification of the polyethylene. Finally, it is also concluded, that the process of mechanical recycling is more appropriate than chemical recycling, since the chemical processes are extremely expensive and technically complex.

Keywords: High-Density Polyethylene, Recycling, Sorting, Quality, Improvement.

iafor
The International Academic Forum
www.iafor.org

Introduction

With the decline of the construction market that we have seen in recent years in Portugal and Spain, companies producing high-density polyethylene were affected by huge reductions in sales volume as well as in the value of sales. This phenomenon has been observed not only in the market of new products (granulated products to be used for the first time in the production of plastic parts from the petrochemical industries), but also in the market of recycled products (although these products are also granulated, they have origin in packaging already treated by the recycling industries).

From the analysis by Nakatani and Hirao (2011), applications for recycled products may be roughly the same as those for new products, depending on the fulfillment of some quality parameters required by the demand, that is, they end up competing in the same markets, for the same customers, and using the same logistic channel. According to Johnson, Scholes and Whittington (2009), and Soares and Mendes (2018), logistics as a primary value chain activity may include the reception, storage and distribution of inputs for the product or service, material handling, stock controls, transportation, storage of outputs or product distribution.

It was in this aggressive, and extremely competitive context, that the company PFAU-PMP contacted with the national recycler "Company ABC" to find solutions that would allow PFAU-PMP to maintain its sales and operational levels. PFAU-PMP is the "Iberian arm" of Hong Kong-based Asia Fukutomi, which operates in the recycling and trading of all types of plastics in the Asian continent.

The analysis by Plasticindustry (2011) shows that the Asian and European markets (natural markets of PFAU-PMP and Company ABC) are fundamental to the polyethylene market, as shown in Figure 1.

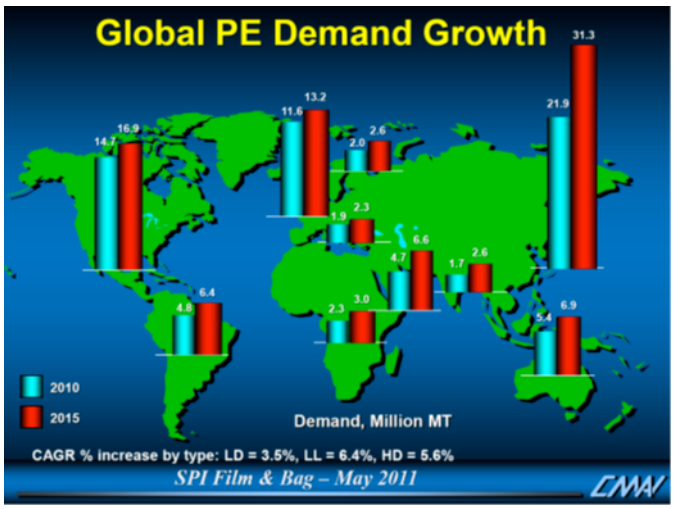

Figure 1 – Global PE Demand Growth
Source: Plasticindustry, 2011.

PFAU-PMP Chemicals Industries y Merchandising Espanola SL, is a company founded in 2002, with headquartered in Cabanillas del Campo in Guadalajara, Madrid, Spain, and it manages all types of plastics, such as polyethylene of high and low density, terephthalate polyethylene, polypropylene, acrylic, polycarbonate, ABS, polystyrene, expanded polystyrene (commonly styrofoam), among many others.

The company's method is to buy bale-shaped products without any prior treatment, in order to guarantee to its Asian counterpart the delivery of quality products and free from contamination (mixing of various plastics), followed by the process of crushing the different types of plastics, which is done internally.

For a 4,000 tons business, such as the one being studied, the company does not have sufficient treatment capacity and it should be assessed specifically from the remaining activity.

PFAU-PMP collects, treats, and sends different types of plastics that, due to their physicochemical characteristics, can be recycled and reclaimed and subsequently reintegrated into the value chain.

The main plastics the company works with are now presented (Figure 2), using information from the British Plastics Federation (2012).

	PET	*polyethylene terephthalate*	*Water bottles, soft and fizzy drink bottles, pots, tubs, oven ready trays, jam jars*
	HDPE	*high-density polyethylene*	*Chemical drums, jerricans, carboys, toys, picnic ware, household and kitchenware, cable insulation, carrier bags, food wrapping material.*
	PVC	*polyvinyl chloride*	*Window frames, drainage pipe, water service pipe, medical devices, blood storage bags, cable and wire insulation, resilient flooring, roofing membranes, stationary, automotive interiors and seat coverings, fashion and footwear, packaging, cling film, credit cards, synthetic leather and other coated fabrics.*
	LDPE	*low density polyethylene*	*Squeeze bottles, toys, carrier bags, high frequency insulation, chemical tank linings, heavy duty sacks, general packaging, gas and water pipes.*
	PP	*polypropylene*	*Polypropylene can be processed by virtually all thermoplastic-processing methods. Most typically PP Products are manufactured by: Extrusion Blow Moulding, Injection Moulding, and General Purpose Extrusion. Expanded Polypropylene (EPP) may be moulded in a specialist process.*
	PS	*polystyrene*	*Toys and novelties, rigid packaging, refrigerator trays and boxes, cosmetic packs and costume jewellery, lighting diffusers, audio cassette and CD cases.*
	Other	*other types of plastics*	

Figure 2 - Typologies and recyclability of plastics
Source: British Plastics Federation, 2012.

The objectives of this paper are as follows:

- Correctly separate the packaging through product quality criteria (color of packaging, process used in the production of packaging, and whether or not polypropylene capsules exist);

- Optimize the quality of the purchased product, giving it the correct processing state (broken, ground or granulated);

- Define which process, mechanical or chemical, is ideal for treating the 4000 tons of polyethylene.
-

Literature review and research questions

Santos (2009) states that while the separation of industrial plastic waste is relatively simple due to the degree of cleanliness of this type of waste, the separation of plastic waste from municipal systems is extremely complex due to contamination and mixing of plastics.

In order to understand better the problem of separation and management of plastic waste by municipal systems, an analysis was made of what is going on in Qatar. Qatar is a small country where the problem of country size does not arise, and where too we find that there is a management entity, the Qatar General Cleaning Project, which, similarly to the management companies in Portugal, is concerned with separating recoverable plastics, such as polyethylene, from other waste that is sent to the landfills. Such landfills do not have active and efficient regulation or supervision, according to Al-Maaded, Madi, Kahraman, Hodzic and Ozerkan (2012). In practice, the authors also make their analysis based on Life Cycle Assessment and not on Quality, recognizing, however, the importance of separating valuable plastics from worthless products or waste.

Given the inability to treat the 4,000 tons of high-density polyethylene internally due to equipment and space constraints, a solution must be found to enables PFAU-PMP to receive and send the product to its Asian counterpart, ensuring the required quality levels, minimizing contamination with other plastics, and maximizing profit for the group.

According to Nakatani and Hirao (2011), the quality of the output of the recycling process depends very much on the quality of the input used. In this case, we can say that the quality depends a lot on the bales collected by the Municipal collection system in Portugal and Spain. According to the information provided by the supplier “Empresa ABC”, most of the high-density polyethylene bales in stock come from the Municipal Waste Management Company in Spain and from Sociedade Ponto Verde in Portugal.

In an attempt to validate the statements of Nakatani and Hirao (2011) where it is stated that the issue of product quality is approached as a “substitution factor or performance ratio”, similar expressions were found in the literature, but always from a perspective not directly related with quality. For example, Lazarevic, Aoustin, Buclet, and Brandt (2010) refer to this issue as “degree of substitution of new product”, under

which a sensitivity analysis could be made by varying this variable alone or in conjunction with other variables, in a context of Life Cycle Assessment (Figure 3).

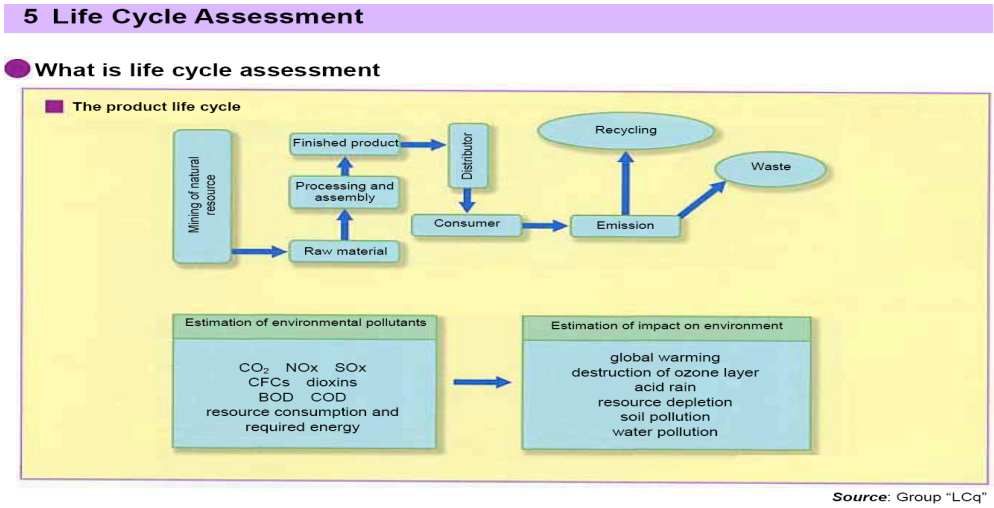

Figure 3 - Life Cycle Assessment
Source: Plastic Waste Management Institute Japan, 2004.

The problem of polypropylene caps placed on packaging, raises yet another quality issue, as it is a known contaminant that deserves special attention from operators, recyclers and academics. Polyethylene and polypropylene appear to be one of the most common mixtures of plastics and therefore it needs a highly optimized screening and selection processes, and to be subject to an efficient quality control as a means of leading to quality certification of products resulting from recycling processes (Serranti, Gargiulo & Bonifazi, 2011).

In order to be able to be efficiently and smoothly reused for the production in which it will be applied, polyethylene must have a quality/separation degree above 97% (Bakker, Rem & Fraunholcz, 2009; Serranti et al., 2011), being the flotation technique the one that guarantees the best quality and efficiency in recovery, according to Bakker et al. (2009). However, this technique is only applied in processes where the material is already in the form of flake, that is, it has already undergone a screening, washing, shredding and grinding process.

Quality is only part of the design of a process of collecting and recycling plastic. Attention is drawn to the fact that this work focuses only on a small part of a very complex problem, and with many interests or factors that condition or complement each other. Figure 4 shows this problem.

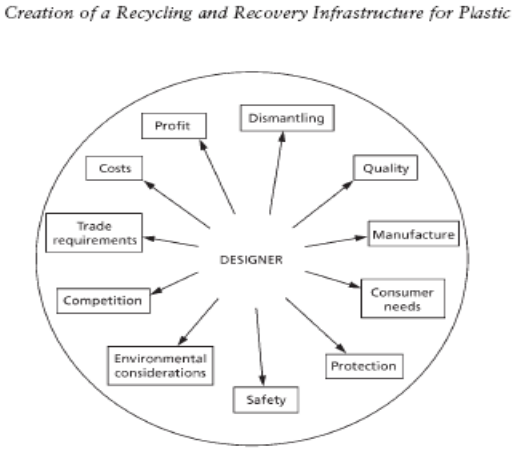

Figure 4 – Creation of a Recycling and Recovery Infrastructure for Plastic
Source: Goodship, 2007.

Plastics are known to occupy large volumes relative to the generality of waste, however this large volume is characterized by low weight, causing problems in transportation. Because of its fundamental importance and perceived cost, transportation has traditionally received a considerable amount of attention from management, with almost all companies, large or small, having transportation managers (Bowersox, Cooper, Closs & Bowersox, 2012; Soares & Mendes, 2017).

In order to avoid high transportation costs and unnecessary space usage, packaging is usually torn apart at the sorting centers, or simply baled, actions also identified in the processing of materials in the recycling units, and where, sometimes, contamination occurs (Kipper, 2005).

Being recognized the importance of input (waste) concerning the quality of output (recycled waste), the role of plastic separation in this process is emphasized. We can say that there are at least two important stages of separation of plastic waste:

- The first occurs at sorting centers, and is the separation of whole or broken packaging;

- The second occurs in the production process of recyclers in the product-shredding phase, and these two points of waste separation are fundamental to product quality (Letras, 2008).

Mattos and Peres (2010) also state that it is only possible to have an effective recycling if the quality of the waste is high, or “the best possible” according to their words. Any dirt or contamination may result in the rejection of a complete batch.

These authors also clearly and explicitly refer to the recycling process as starting with packaging, collecting and sorting, then grinding and milling, with the aim of producing granules or flakes that can be incorporated into the production of new products.

We are now in a position to continue research on the quality issue of recyclable (input) and recycled (output) products, bearing in mind that large organizations such as ABC Company have little incentive to invest in quality, because they consider that their size and capacity are considered robust barriers to the entry of new competitors (McIntyre, 2011).

The analysis will take into account the suggestion made by Sun and Zhao (2010), who mention that quality systems based on Total Quality Management also aim to improve product and process quality.

Finally, looking at recycling companies not only as purely productive and industrial units, but also as companies that render services to society, we can say that Soares (1994, 2003) considers that the most relevant trends for the future are the increase of quality in service companies, due to the increasing weight of services in the current economy, and the extension of quality operations to all functions and hierarchical levels of an organization.

Research questions

Therefore, this study aims essentially to answer three research questions:

- How to proceed with the correct separation of the packaging, through product quality criteria?

- How to optimize product quality by giving it the correct processing state (shredded, milled (crushed) or granulated)?

- Is it possible to define which of the processes, mechanical or chemical, is ideal for treating 4000 tons of polyethylene?

Methodology

The study is based on the direct observation at the place where the 4000 thousand tons of polyethylene are stored, and the need to treat them. There is a clear lack of space on the part of PFAU-PMP to receive all quantities.

Several informal interviews were also conducted with the heads of the companies involved in this project, and the flow and production scheme of the ABC Company unit was also observed and recorded.

A comparative analysis of the different waste treatment methods (mechanical and chemical) will be made, and it will be determined which one gives the best quality to the final product.

An analysis will also be carried out on the best processing status to be given to the product (shredded, milled (crushed) or granulated) through interviews with ABC Company, PFAU-PMP, Fukutomi and two consumers of the new and recycled products. Please note that here Fukutomi will also be interviewed as a consumer of polyethylene as it develops both activities.

In the analysis by direct observation in the place where the 4000 tons of polyethylene are stored (ABC's raw material park), it was possible to find and classify 3 types of polyethylene packaging from 2 different sources:

- White, cream and multi colored (blue, green, yellow, pink) packaging;
- Packaging from the detergent industry or the food industry.

It was also observed that at the time of opening the polyethylene bales, other materials were present such as polypropylene and PET, and within the polyethylene, high and low density polyethylene were also identified.

In an interview with ABC's technical manager, it was mentioned that the most efficient and economic method from an industrial point of view was mechanical recycling, which starts with the separation process. Melo (2009) states that this step consists in the separation of contaminants, that is, it consists in removing materials other than those that will be recycled, and this process can be manual or automatic.

According to Spinace and De Paoli (2005) and Schlischting (2003), the product resulting from the recycling process can be reused in traditional injection, extrusion and blowing processes, where it can be mixed with new materials to compensate for the loss of quality observed during reprocessing.

However, those responsible stated that the need to use virgin raw material to address the quality flaws of the recycled product varies depending on the final application, and the characteristics of the recycled product itself.

Letras (2008) analyzes the quality criteria required for recycled polymers, stating that impurity limitations should be below 1% m/m (solute mass per solvent mass).

We present now a diagram of the simplified flow of the production process, to suggest improvements in the product quality (Figure 5):

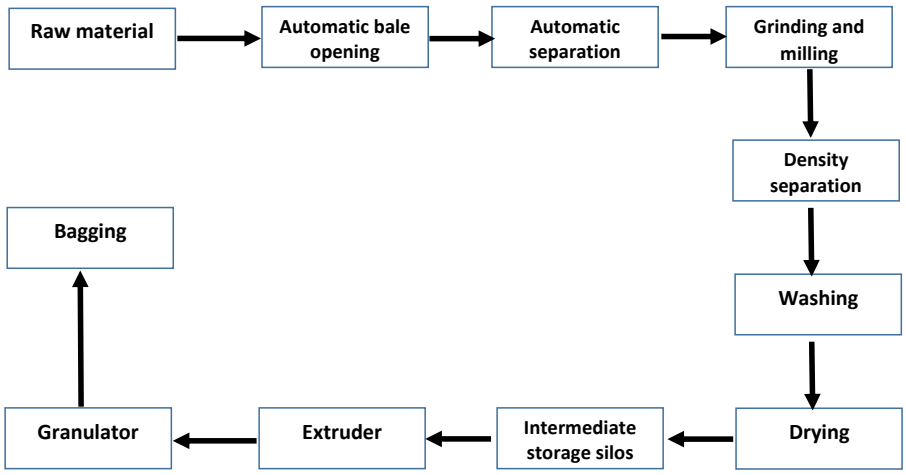

Figure 5 – Simplified flow of the production process
Source: Authors.

As this analysis refers to a company that buys most of its raw materials for recycling in the public auctions of Sociedade Ponto Verde (SPV), it is known the maximum percentage of contamination that the company should eliminate is 12% of the total weight of the material under analysis.

If we are analyzing a 4000 tons batch then a maximum of 480 tons of contaminants will have to be eliminated, which in practice translates into a high risk concerning product quality. Therefore, the concern about identifying the best method of treatment for the 4000 tons, because as mentioned above, the maximum impurities allowed in the recycled end-product should be 1% m / m (solute mass per solvent mass), that is 11% of the total contaminants allowed by the Sociedade Ponto Verde specifications.

Crossing this data with the theoretical conclusions of the different authors, as well as with the results of the interviews with the managers of the companies involved, it is proposed to create an alternative flow, and to make recommendations that aim to fulfill the objectives of the work performed, and to answer the research questions.

Results analysis and discussion

For recycling to happen the product has to be recyclable, and the process economically viable (Mattos & Peres, 2010). But for the (new) product resulting from the recycling process to be increasingly cost effective, improving product quality must be accompanied by a time to market process so that its profitability is high (McNally, Akdeniz & Calantone, 2011).

Due to its size and production capacity and the technical skills of its employees, ABC Company is in a position to shorten its time to market.

Still, the process of quality control of raw materials which is of utmost importance to the quality of the final product (Nakatani & Hirao, 2011) is neglected to the point that no prior separation of materials is made. This is verified by visual inspection of the 4000 tons, according to the photographic record in Figures 6, 7 and 8.

Figure 6 - Photo 1 of 4000 tons of High Density Polyethylene
Source: Authors.

Figure 7 - Photo 2 of 4000 tons of High Density Polyethylene
Source: Authors.

Figure 8 - Photo 3 of 4000 tons of High Density Polyethylene
Source: Authors.

It can be seen that the packaging in the bales are the most diverse, in terms of both geographical origin, color, and the type of product the packaging has packed.

It is understood that a condition of improvement of product quality would be the one mentioned by Nakatani and Hirao (2011) and Grach (2006), that is the input control of raw materials should be manually screened before entering the automatic sorting systems. By doing this, it would be possible to extract some contaminants not identified by the automatic systems, and reduce the color mix of the final product.

It should be noted that in interviews with the heads of Fukutomi and PFAU-PMP, it was mentioned that the final product was more valued the lighter the color, as with light colors it would be possible to place additives to continue producing material in light colors, while dark colors can only produce black materials again.

In terms of presentation of the final product, it was found that ABC Company is able to do any of the following processes, which are to wreck with a 30 to 50 mm sieve, to grind with a 12 mm sieve, or to granulate and extrude.

After some calculations and considering the information provided by the Fukutomi manager, the grinding with a 12mm sieve was considered the most logistically viable option.

Conclusions and recommendations

After the conclusion of this study we can draw some conclusions regarding the objectives initially proposed, and can then say that concerning the first research question, it is possible to improve the quality of the final product by introducing a manual sorting mat prior to the automatic sorting process, allowing correct color separation and removal of contaminants.

Addressing the second research question, it was concluded that the best presentation of the product is milled (crushed) to 12 mm, because it has a lower logistic cost when compared to the shredded to 30-50 mm, and has a lower cost of import in China when compared to the granulated.

Regarding the third research question, it was concluded that the mechanical recycling is more appropriate than chemical recycling, and is thus identified as the ideal method of treating the 4000 tons of high-density polyethylene, since the chemical processes are extremely expensive and of great technical complexity, as mentioned by Pereira (2002).

We can conclude by saying that one of the limitations of this study was the impossibility of immediately implementing the theoretical recommendations presented to the company's managers.

As a final recommendation, it is proposed to the company to gradually introduce the suggested proposals in order to be able to solve the problems of plastic separation.

References

Al-Maaded M., Madi N. K., Kahraman R., Hodzic A., & Ozerkan N. G. (2012). An Overview of Solid Waste Management and Plastic Recycling in Qatar. *Journal of Polymers and the Environment, 20*(1), 186-194.

Bakker, E. J., Rem, P. C., & Fraunholcz, N. (2009). Upgrading mixed polyolefin waste with magnetic density separation. *Waste Management, 29*(5), 1712-1717.

Bowersox, D. J., Closs, D. J., Cooper, M. B., & Bowersox, J. C. (2012). *Supply Chain Logistics Management* (4th ed.). New York: McGraw-Hill.

British Plastics Federation. (2012). *Identifying Plastics Marking Systems for Plastics Products.* Retrieved 02 December 2015 from http://www.bpf.co.uk/Sustainability/Plastics_Recycling.aspx#identifyingplasticsmarkingsystemsforplasticsproducts.

Goodship, V. (2007). *Introduction to Plastics Recycling* (2nd ed.). Shropshire, UK: Smithers Rapra Technology Limited.

Grach, F. C. (2006). *Incorporação de resíduos de embalagens pós-consumo provenientes das agroindustrias na fabricação de bandejas de polpa moldada*. Unpublished Master dissertation, Federal University of Santa Catarina, Santa Catarina, Brasil.

Johnson, G., Scholes, K., & Whittington, R. (2009). *Fundamentals of Strategy.* Harlow: Prentice Hall.

Kipper, L. M. (2005). *Ações estratégicas sistémicas para a rede sustentável de reciclagem de plásticos*. Unpublished PhD dissertation, Federal University of Santa Catarina, Santa Catarina, Brasil.

Lazarevic, D., Aoustin, E., Buclet, N., & Brandt, N. (2010). Plastic waste management in the context of a European recycling society: Comparing results and uncertainties in a life cycle perspective. *Resources, Conservation and Recycling, 55*(2), 246-259.

Letras, M. C. (2008). *Reciclagem de Plásticos: Identificação de contaminantes e estratégias de valorização dos resíduos industriais.* Unpublished Master dissertation, New University of Lisboa, Lisboa, Portugal.

Mattos, N. C. M., & Peres, P. E. C. (2010). Coletar e reconhecer o plástico: Uma atitude em educação ambiental. *Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental, 1*(1), 1–12.

McIntyre, D. P. (2011). In a Network Industry, Does Product Quality Matter? *Journal of Product Innovation Management, 28*(1), 99–108.

McNally, R. C., Akdeniz, M. B., & Calantone, R. J. (2011). New Product Development Processes and New Product Profitability: Exploring the Mediating Role

of Speed to Market and Product Quality. *Journal of Product Innovation Management, 28*(1), 63-77.

Melo, C. K. (2009). *Reciclagem de materiais poliméricos por incorporação in situ na polimerização em suspensão do estireno*. Unpublished Master dissertation, Federal University of Rio de Janeiro, Rio de Janeiro, Brasil.

Nakatani, J., & Hirao, M. (2011). Multicriteria Design of Plastic Recycling Based on Quality Information and Environmental Impacts. *Journal of Industrial Ecology, 15*(2), 228-244.

Nakatani, J., & Hirao, M. (2011). Multicriteria Design of Plastic Recycling Based on Quality Information and Environmental Impacts. *Journal of Industrial Ecology, 15*(2), 228-244.

Pereira, F. A. G. (2002). *Um estudo sobre reciclagem de embalagens plásticas de óleo lubrificante pós-consumo.* Unpublished Master dissertation, Federal University of Rio de Janeiro, Rio de Janeiro, Brasil.

Plastic Waste Management Institute Japan. (2004). *An introduction to Plastic Recycling*. Retrieved 23 March 2014 from http://www.pwmi.or.jp/ei/plastic_recycling_2009.pdf .

Plasticindustry. (2011). *Future of Film and Bag conference Attendees and Presentations*. Retrieved 03 March 2016 from http://www.plasticsindustry.org/IndustryGroups/content.cfm?ItemNumber=6456.

Santos, L. R. N. (2009). *Avaliação da Eficiência da Separação de Plásticos de Resíduos Sólidos Urbanos por Métodos de Dissolução Seletiva.* Unpublished Master dissertation, University of Minho, Guimarães, Portugal.

Schlischting, R. (2003). *Influência da Adição de Poliestireno Expandido no Processo de Polimerização do Estireno em Suspensão.* Unpublished Master dissertation, Federal University of Santa Catarina, Santa Catarina, Brasil.

Serranti, S., Gargiulo, A., & Bonifazi, G. (2011). Characterization of post-consumer polyolefin wastes by hyperspectral imaging for quality control in recycling processes. *Waste Management, 31*(11), 2217-2227.

Soares, J. M. (1994). *A Qualidade nos Serviços em Portugal – Ponto da Situação nos Sectores Bancário e Segurador*. Unpublished Master dissertation, ISEG – Lisbon School of Economics & Management, Lisbon, Portugal.

Soares, J. M. (2003). *A Study of the Influence of Cultural Differences on Perceptions of Quality in Retail Banking in England, Portugal and Spain*. Unpublished PhD dissertation, University of Kent, Kent, England.

Soares, J. M., & Mendes, F. (2017). Analysis and Improvement of the Management of Stocks in 'Vasco da Gama' Frigates - A Practical Study. In *The European Conference on Sustainability, Energy & the Environment 2017: "East Meets West: Innovation*

and Discovery", Official Conference Proceedings (pp. 165-184). Nagoya, Japan: The International Academic Forum (IAFOR).

Soares, J. M., & Mendes, F. (2018). Restructuring of the System of Storage and Dispatch of Portuguese Air Force (PAF) Material. In *The European Conference on the Social Sciences 2018: "Surviving & Thriving in Pursuit of a Sustainable World", Official Conference Proceedings* (pp. 39-54). Nagoya, Japan: The International Academic Forum (IAFOR).

Spinacé, M. A. S., & De Paoli, M. A. (2005). A Tecnologia de Reciclagem de Polímeros. *Química Nova, 28*, 65-72.

Sun, H., & Zhao, Y. (2010). Total Quality Management & Business Excellence. *Total Quality Management, 21*(4), 351-361.

Contact email: josesoares@iseg.ulisboa.pt

Investigation of the Best-case Scenario of Rice Husk/Briquette Combustion for Lower Particulate Matter Emission

Emmanuel Abah, University of Tsukuba, Japan
Ryozo Noguchi, University of Tsukuba, Japan

The European Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
The combustion of biomass such as rice husk, remains the most popular and commercial method for its energy utilization. However, its combustion is an important source of particulate matter (PM) emissions, which forms a crucial part of air pollution. This study investigated the effects of particle size of rice husk and bran impurities on the emission trend of $PM_{2.5}$. Commercial rice husk was obtained from a Japanese rice husk company and was prepared into 3g as JPN samples. They have no bran impurities and consist of normal sized Japonica husk particles (4 – 5 mm). Rice husk sample was imported from Nigeria under permission. The imported rice husk was obtained from rural milling centers in Nigeria. They are smooth and consist of smaller rice husk particles (0.1 – 2 mm) and has bran impurities. Rice husk briquette was obtained from Tromso Co., Ltd, Japan and were prepared into 3g as RB samples. The three samples were combusted in temperatures between 600°C – 1000 °C for 5 minutes resident time. The experimental set up comprises of a Yamato F100 fixed bed electric furnace attached with a fabricated tubular heat exchanger, connected to a coolant, a Dust Track II aerosol analyzer. Interestingly, RB samples recorded the highest average $PM_{2.5}$ emission (57.9 mg/m^3) at a temperature of 750 °C compared to that of NGR husk (39.0 mg/m^3) at 750 °C, and JPN samples (27.8 mg/m^3) at 900 °C. Interparticle space, density and particle size were the crucial factors that had significant influence on the emission trend.

Keywords: particulate matter (PM), $PM_{2.5}$, combustion, emission, particle size, density, rice husk

iafor
The International Academic Forum
www.iafor.org

Introduction

Bioenergy generation have been in an upward trajectory since 2015, contributing in meeting the rising demand for energy in many countries while contributing to environmental objectives. Though, the sector has encountered challenges such as low oil prices and the policy of uncertainty in some markets (. Renewables 2016). Heat energy utilization accounted for approximately half of total global energy consumption in 2015 (IEA 2015). Global heat energy consumption increased at a mean yearly rate of about 1% (IEA 2016). In 2015, bioenergy's share of final energy utilization for heating was 25%; of this amount, nearly all of it was from traditional biomass, mostly in developing countries (IEA 2015).

While biomass combustion remains a popular and commercial method for energy generation, its combustion is an important source of particulate matter (PM) emissions, which forms a key part of air pollution. Air pollution from biomass combustion is regarded as the third largest contributor to the global burden of disease (Klasen et al., 2015). Inefficient combustion of biomass fuels emits a complex mixture of carbon monoxide (CO), PM, and other harmful gases (Abah et al., 2018). The combustion of biomass with high silica ash content such as rice husk, could lead to the emission of fibrous PM and crystalline silica, which has the potential of causing significant health problems (Gilbe et al., 2008). Studies have shown that emissions from biomass combustion is heavily dependent on temperature (Abah et al., 2018), fuel properties and air-to-fuel ratio Nussbaumer 2003).

Knowledge of specific fuel properties and specific combustion system such as fixed bed or natural draught system is needed in developing measures for emission control since pollutant emission (CO, soot and PAH) occurs due to incomplete combustion. Natural draught systems such as open-air combustion or simplified brick combustion system and other similar fixed bed combustion systems are still being used extensively in developing countries, especially in rural areas. These systems are inefficient and serve as key cause of pollution. Assessment of these systems in terms of PM emission is therefore required in for mitigating air pollution.

Therefore, it is imperative to examine the best-case scenario of rice husk combustion that emits lower PM emissions. Similarly, to know how to control PM emissions if the biomass fuel is transformed during its formation process due to the use of a given technology. Therefore, this study evaluates $PM_{2.5}$ emissions from rice husk combustion in a fixed bed combustor for 3 minutes duration. This study is limited to particulate matter of size fraction 2.5 μm. The experiment was conducted in laboratory, using a small-scale fixed bed incinerator. Consequently, the size per sample was limited to 3g

Experimental methods

Three different groups of samples were used for the combustion experiment. The first group refers to commercial rice husk that was obtained from a Japanese rice husk company and was prepared into 3g as JPN samples. They have no bran impurities and consist of normal sized Japonica husk particles (3 – 4 mm). The second group refers to rice husk samples imported from Nigeria under permission. The rice husk was obtained from rural milling centers in Nigeria and was prepared into 3g as NGR

samples. They are smooth and consist of smaller rice husk particles (0.1 – 2 mm) and has bran impurities. These peculiar properties were due to the type of rice milling technology used in the rural areas (single pass milling machines). Single pass milling involves the removal of husk and bran in a single operation. The machine comprises of steel rollers which removes the husk and the bran. These machines generate a mixture of rice husk dust and bran.

The third group of samples refers to rice husk briquette obtained from Tromso Co., Ltd, Japan and were prepared into 3g as RB samples. These rice husk briquettes were made without the use of a binding material. They were grinded and compressed at temperatures below 300 °C. The JPN, NGR and RB samples were then separately combusted in temperatures between 600°C – 1000 °C using a fixed bed combustor. The resident time for each combustion experiment was 5 minutes. The experiment was conducted on a laboratory scale. The experimental set up comprises of a Yamato F100 fixed bed electric furnace attached with a fabricated tubular heat exchanger, connected to a coolant, and a Dust Track II aerosol analyzer (**Fig. 1**). The dust track II aerosol analyzer is a real-time PM counter, with a standard air flow rate of 3 L/min and uses size selective cascade impactors.[5] The targeted emission measurement for this experiment is $PM_{2.5}$.

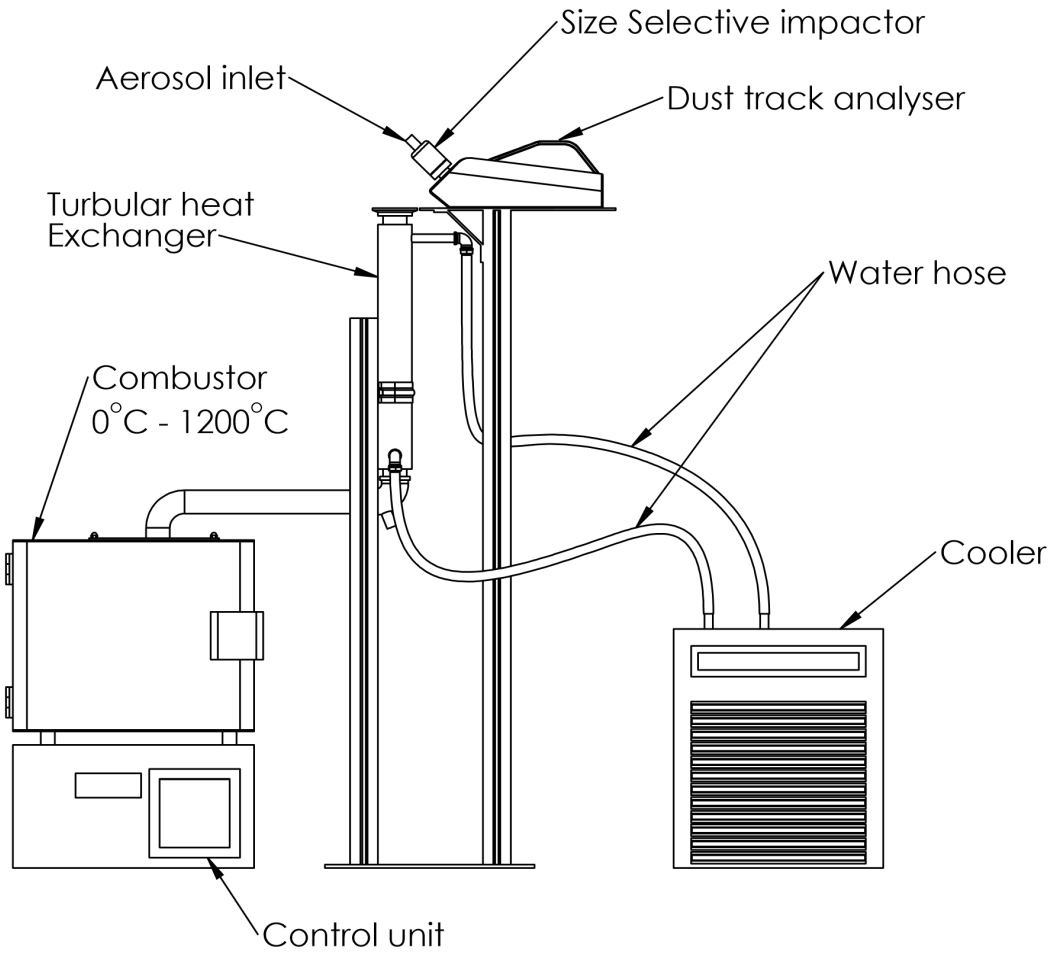

Figure.1 Experimental set-up for $PM_{2.5}$ measurement (Abah et al., 2018)

Results and discussion

The login interval for the data collection for the dust track II instrument was set at 10 secs. A total of 30 points data for 300 secs (5 minutes) was recorded by the instrument for each temperature category (600°C, 650°C, 700°C, 750°C, 800°C, 850°C, 900°C, 950°C, and 1000°C). The average $PM_{2.5}$ represent the average of the experimental result data recorded for each temperature category. **Fig. 2** presents the combined comparative result of $PM_{2.5}$ emission from the combustion of JPN, NGR and RB samples.

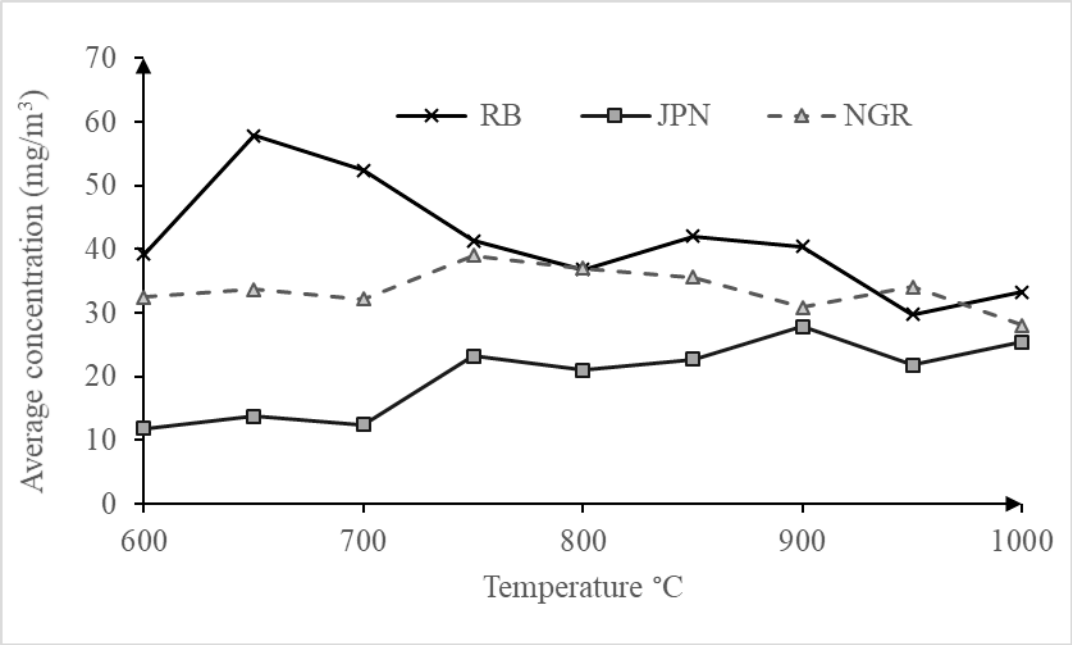

Figure 2. Comparative analysis of $PM_{2.5}$ emission from the combustion of JPN, NGR and RB samples.

$PM_{2.5}$ emission from the combustion of JPN husk increases from a minimum of 11.8 mg/m^3 at 600°C to its maximum of 27.8 mg/m^3 at 900°C. Emission from the NGR husk was notably higher due to its smaller size rice husk particles and bran impurities which increased the density. Therefore, the high $PM_{2.5}$ emission from the combustion of NGR husk was due to the higher density resulting in low interaction between the combustion air and the rice husk fuel particles. More so, the low pore spaces decrease the thorough mixing of the combustion air and the rice husk fuel, indicating the possibility of uneven combustion. As a result, the top portion of the sample is exposed to more combusted air and gets burnt faster than the bottom. This is common to fixed bed combustion system with no bottom air vent.

Porteiro reported in his study that, mean particle size, particle density, bed density and porosity are the key aspect of fuel morphology that influences fixed bed combustion systems as in terms of combustion efficiency (Porteiro et al., 2010). JPN husk sample has large interparticle spaces and ensures that the combustion air can mix better with the fuel, thereby leading to lower emission. This result agrees with previous studies that particle size, fuel density and porosity affect combustion rate, which in turn affects $PM_{2.5}$ emission (McKenzie et al., 1995, Launhardt et al., 1998, Bonjour et al., 2013,). Therefore, lower temperature (600 °C) of combustion of JPN and NGR rice

husk, favors the lowest $PM_{2.5}$ emission in this study. This agrees with Abah, who reported low PM emission at 700 – 800 °C. For JPN and NGR, emission increases as the temperature increases (Abah et al., 2018). However, emission pattern from the combustion of the RB samples differs. In this case, emission decreases as temperature increases. This is because, the compression of rice husk into briquette increases its density and calorific value and are optimized when combusted at higher temperatures for longer time. This explains why RB combustion at 950 °C emitted lower $PM_{2.5}$ (29.8 mg/m^3) compared to its combustion at 650 °C.

The electric furnace has a constant supply of excess air to the combustion chamber. This could lower the temperature in the combustion chamber, especially for the RB combustion. Thus, leading to inefficient combustion and high $PM_{2.5}$ emission. Singh et al., reported that higher excess air in the combustion chamber, decreases the temperature of combustion, thus leading to a poor combustion (Singh and Kashyap 1985). Loosed rice husks (JPN and NGR) can be easily fluidized by air in the combustion chamber and thus, lesser $PM_{2.5}$ emission. RB due to its higher bulk density cannot be fluidized and burns in a fixed position therefore, lesser air-to-fuel mixing, consequently more $PM_{2.5}$ emission. Characteristically, briquettes (RB) is a high bulk density fuel and requires longer combustion time, which could lead to more emission. Urbanski reported that as the fuel bulk density increases, the combustion efficiency decreases and emission of CO, CH_4 and $PM_{2.5}$ increases (Urbanski et al., 2016).

Conclusion

This study investigated the effects of particle size of rice husk and bran impurities on the emission trend of $PM_{2.5}$. RB samples emitted the highest $PM_{2.5}$ followed by NGR and JPN samples respectively. The flaming phase of the combustion emits less $PM_{2.5}$ emission compared to the smoldering phase. The RB combustion predominantly occurred in the smoldering phase due to its compact nature and less interparticle space. The JPN combustion was predominantly flaming phase as a result of the better interaction of the fuel particles and air due to its larger interparticle space. This study has expanded the findings of other studies that particle size affects combustion efficiency and, particulate matter emission. The study showed that the combustion of briquette in fixed bed systems at low temperatures, emits higher particulates emission. This study recommends the combustion of briquette at higher temperatures to minimize the emission of particulate matter. Alternatively, adequate particulate matter removal systems should be installed to mitigate public health risk.

Acknowledgement

The authors would like to thank Mr. Yasuyuki Hidaka (National Agriculture and Food Research Organization, Japan) for providing support and instrumentation for this study. We would like to thank the Nigeria Ministry of Agriculture and Rural Development for granting permission for this study.

References

Renewables (2016). Global Status Report. REN 21

IEA (2015). Medium-Term Renewable Energy Market Report, op. cit. notes 31

IEA (2016). Electricity Information, preliminary edition (Paris: 2014).

Klasen, E.M., Wills, B., Naithani, N., Gilman, R.H., Tielsch, J.M., Chiang, M., Khatry, S., Breysse, P.N., Menya, D., Apaka, C., Carter, E.J., Sherman, C.B., Miranda, J.J., Checkley, W., and COCINAS Trial Working Group (2015). Low correlation between household carbon monoxide and particulate matter concentrations from biomass-related pollution in three resource-poor settings. *Environmental Research 142 424 – 431*. http://dx.doi.org/10.1016/j.envres.2015.07.012

Abah, E.O., Iwai, K., Sakurai, K., and Noguchi, R (2018). Comparative Real-time Assessment of Particulate Matter Emissions in Rice Husk Combustion. *Journal of the Japan Institute of Energy, 97, 222-225.* https://doi.org/10.3775/jie.97.222

Gilbe, C., Öhman, M., Lindström, E., Boström, D., Backman, R., Samuelsson, R., Burvall, J. (2008). Slagging characteristics during residential combustion of biomass pellets. *Energy and Fuels, 22 (5), 3536-3543.* https://doi.org/10.1021/ef800087x

Nussbaumer, T. (2003). Combustion and Co-combustion of Biomass: Fundamentals, Technologies, and Primary Measures for Emission Reduction. *Energy & Fuels 17, 1510-1521.* https://doi.org/10.1021/ef030031q

Porteiro, J., Patino, D., Miguez, J.L., Granada, E., Moran, J., Collazo, J. (2010). Study of the reaction front thickness in a counter-current fixed-bed combustor of a pelletized biomass. *Combustion and Flame 159(3): 1296 – 1302* https://doi.org/10.1016/j.combustflame.2011.10.007

McKenzie, L.M., Hao, W.M., Richards, G.N., Ward, D.E. (1995). Measurement and Modeling of Air Toxins from Smoldering Combustion of Biomass. *Environmental Science & Technology, 29: 2047-2054.* https://doi.org/10.1021/es00008a025

Launhardt, T., Strehler, A., Dumler-Gradl, R., Thoma, H., Vierle, O. (1998). PCDD/F- and PAH-emission from house heating systems. *Chemosphere, 37: 2013-2020.* https://doi.org/10.1016/S0045-6535(98)00265-3

Bonjour, S., Adair-Rohani, H., Wolf, J., Bruce, N.G., Mehta, S., Pruss-Ustun, A., Lahiff, M., Rehfuess, E.A., Mishra, V., and Smith, K.R. (2013). Solid Fuel Use for Household Cooking: Country and Regional Estimates for 1980–2010. *Environmental Health Perspectives.* https://doi.org/10.1289/ehp.1205987

Singh, D. and Kashyap, M.M. (1985). Mechanical and Combustion Characteristics of Paddy Husk Briquettes. *Agricultural Wastes (13) 189 – 196.* https://doi.org/10.1016/0141-4607(85)90033-2

Urbanski, S.P., Baker, S.P., Lincoln, E., Richardson, M. (2016). The Influence of Fuel Properties on Combustion Efficiency and the Partitioning of Pyrogenic Carbon. *American Geophysical Union.* http://adsabs.harvard.edu/abs/2016AGUFM.B21M...07U

Contact email: noguchi.ryozo.gm@u.tsukuba.ac.jp

People's Engagement With Renewable Technologies - Roadblocks and Triggers

Hamilton V. Niculescu, Dublin City University, Republic of Ireland

The European Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
This paper discusses early findings on my ongoing constructive grounded theory study looking at people's engagement with mobile communication technologies and remote, sustainable automated systems. Based on qualitative data generated following in-depth semi-structured interviews with 12 people living in Ireland, corroborated with quantitative data generated by the automated system, this papers argues that ownership plays an vital role in people engaging with and adopting new technologies. Also, while people demonstrated having mixed feelings about renewable energy sources, being perceived as expensive and unreliable, the participants expressed their interest in changing their lifestyle and adopting newer energy sources, with the intention of becoming independent from the national grid, which is also being perceived as unreliable. Additional information about this ongoing project can be found at http://eyeduinoproject.online/

Keywords: sustainability; engagement; automation; technology; empowerment; ownership

iafor
The International Academic Forum
www.iafor.org

List of figures

Introduction

This mixed methods research aims at developing insights in relation to urban Irish population's interaction with (renewable) technologies, and uncover triggers and roadblocks that are preventing for such interactions to take place. Six automated enclosures, at six different locations in Dublin, Republic of Ireland were built in order to facilitate the qualitative data collection. The enclosures allow the 18 human participants to grow vegetables, each participants having full monitoring and control over the functionality of one of such enclosures. Participants' aim is to ensuring optimal growing conditions for plants to grow inside the enclosures, by means of working physical devices such as windows, ventilation fans, and irrigation. These tasks can be performed remotely, by using a custom developed mobile phone app, in accordance with in-app provided climate information.

Engagement details are recorded on an online server, providing time stamped data in relation to current conditions inside each enclosure, any action taken by the participants, and system's working mode (automatic and manual). The quantitative data will complement the main qualitative data obtained following focus group discussions, semi-structured interviews, observations, and memo analysis, acting at the same time as validation for the ongoing data collection and analysis.

Current literature

We are continuously being warned that the current 'business as usual' economy model can no longer continue. There are signals that the 'cheap food' era is coming to an end, and that more sustainable development policies should be advanced and implemented (Moore, 2010; Morgan, 2016; Räthzel & Uzzell, 2017). Niche innovations might represent an important step towards sustainable development and systemic change (Geels, 2011). They could bring the necessary societal changes in regards to transport, energy, and food, by means and with the help from new legislation, infrastructure, technology and knowledge (Elzen, Geels, & Green, 2004; Geels, 2004; Grin, Rotmans, Schot, Geels, & Loorbach, 2010).

Actor Network Theory asserts that in order for the transition process to be successful, all relationships between humans and non-humans (such as technologies, objects, nature, etc.) should be analysed together, as hybrid 'society-nature' bodies, rather than in isolation, for they are mediating and shaping each other (Latour, 1993; Michael, 2000). Taylor, Clarke, Skelly, & Nevay (2018) recommend that '*further work must*

continue to explore how neighbourhoods can better take ownership not just of the technology, but of the processes that develop them' (Taylor, Clarke, Skelly, & Nevay, 2018:10).

Is simply not enough to providing hardware support, and then expect people to learn the necessary skills to actually using it, without foreseeing any benefit in doing this. It takes more than addressing any 'equipment gap' in order to promote information communication technologies in society. Individual's experience of, and attitudes towards, using technologies plays an important factor as well (Selwyn, 2003; Silverstone, 2005). It has also been suggested that because sustainability brings no individual advantages, but rather contributes to a 'collective good', without meaningful economic changes it implies that innovations will have a low impact when it comes to replacing long, already established technologies (Geels, 2011).

Our planet's 3.8 billion years old natural Research and Development could be used as an inspiration to developing recyclable and biodegradable materials, in a process called 'biomimicry' or 'biomimetics' (Benyus, 2002; Blok & Gremmen, 2016), PV solar panels being compared to leafs for instance. Sandel (1997) suggests that more diverse R&D processes, as well as a creating strong communication channels with society and stakeholders, represent an important step towards acceptance and desire for sustainable innovations as well as for societal change (Sandel, 1997).

Existing knowledge

People which are inclined to test and find new meanings for emerging innovations are also more likely to later adopt them (Ramirez-Portilla, Cagno, & Trianni, 2014). Different views of the same artefact need to be considered as well, images of the same greenhouse having interpreted by various people as change of energy use, or as a means to avoiding waste (Henwood, Shirani, & Groves, 2018).

Senior citizens are less likely to adopt new technologies (Gilly, Celsi, & Schau, 2012), while local communities concerns should be addressed before starting a large scale project (Enevoldsen & Sovacool, 2016). This could be done by implementing similar small scale projects, while providing education, knowledge, and financial support for start-up sustainable businesses (Augustenborg et al., 2012; Qureshi, Ullah, & Arentsen, 2017). This might play an important role in *leapfrogging* – jumping from primitive technologies to sustainable ones (Sarabhai & Vyas, 2017). It is argued however that higher education does not guarantee an increase in regards to renewable adoption rate, and instead the wealthy population are more likely to adopt (Smith & Urpelainen, 2014).

Perceived relative advantage of technology, complexity of the innovation, social influence, and knowledge about grants and costs were advanced as indicators in relation to factors that would influence the adoption of photovoltaic (PV) solar panels (Vasseur & Kemp, 2015). Overall, the financial status was identified as being the main factor when it comes to (non-)adoption of PV panels. (Saka, Olawumi, & Omoboye, 2017). In spite of an initial high interest into adopting solar panels, and after identifying their relative advantage, lack of finance proved to be a huge barrier (Faiers & Neame, 2006).

Methodology and technical considerations

My study adopts a constructivist grounded theory approach, made popular by Katy Charmaz, and the ongoing data collection is based on focus group discussions, in-depth semi-structured interviews, and observations (Alemu, Stevens, Ross, & Chandler, 2015; Mills, Bonner, & Francis, 2006). Detailed analytical memos offer support for current data analysis process, and will serve as a critical framework for building the theory towards the end of the study (Charmaz, 2006). The research process was designed in such a way that each participant is interviewed twice (before and after engaging with the automated system) to allow for collecting and interpreting of different experiences, related to interdisciplinary fields.

Developed in 1967 by Barney Glaser and Anselm Strauss, grounded theory (GT) research is based on reflexive interpretation of qualitative data mainly obtained following interviews, questionnaires, and observations of participants (Birks & Mills, 2011). The emerging theory aims at explaining the phenomenon being studied, through the perspective and interpretation of the researcher (Birks & Mills, 2011; Creswell, 2007; Strauss & Corbin, 1994).

By using a custom developed mobile phone app, participants in this study are using their smart devices in order to operate remote physical devices such as irrigation valves, windows and ventilation fans. Their aim is to ensuring optimal growing conditions for plants inside purpose-built enclosures (greenhouses), by way of monitoring and controlling values related to soil moisture, air temperature and humidity. Although the idea of using a smart phone to controlling remote devices may not be necessarily new to people – such as using it to set the heating, or control lights in their household for instance – by emphasising the fact that it is their responsibility to keep some plants alive may add to participants' emotional impact. Also, because the automation systems are powered solely by means of renewable technologies (photovoltaic panels), the participants are expected to be aware of the amount of available electricity when operating devices, and avoid draining the battery.

In constructivist GT, the data is interpreted following an induction process of the researcher, and therefore the phenomenon described may not be an exact representation of reality, but an interpreted portrayal (N. Denzin & Lincoln, 2005; Kennedy & Thornberg, 2018). During the course of this study, reflexivity, using mixed methods of data collection, and triangulation of data are employed during data collection and analysis, in an attempt to capture truthful representation of complexities, views and actions of lived reality, without making false claims that they are offering and explanation of the 'whole picture' (Charmaz, 2006). Following final data analysis, details will emerge in relation to peoples' engagement with specific communication technologies, i.e. their familiar mobile phones, in order to control remote devices aimed at achieving tasks which may be new to them.

Considering the limited amount of research locations (six), and also for practical purposes, both theoretical and purposeful samplings were used for recruitment of participants. This maximised the opportunities to developing of concepts (ongoing) and their relationship, as well as discovering and comparing variation of information rich data. Participants were mainly recruited from amongst members of community

gardens, with the view that they would already be familiar with the location, and would have at least some gardening experience, so that they are not potentially distracted by the newness of such activities. A few negative/deviant cases were chosen, and they will prove crucial for testing the theory towards the end of the research (N. K. Denzin & Strauss, 2003; Flick, 2011; Maxwell, 1996; Pickering, 2008).

Having theoretical and methodological triangulation applied to collected data (via focus group discussions, individual interviews and on going observations), early findings, patterns and themes emerged, allowing for discussion and intermediate conclusions to be drawn (Flick, 2018). This paper discusses findings related to peoples' recycling practices, sustainable lifestyles, and engagement with technology, based on partial data collected by way of qualitative interviews conducted between March – June 2019.

By sacrificing scope for detail, smaller sample sizes allow for better in-depth analysis of social, cultural and economic factors of each participant, as the data resulting from just one interview can be quite extensive. The recommended average sample size for qualitative research is anywhere from 1 to 20 participants (Birks & Mills, 2011; Brinkmann, 2013; Davies, 2007; Maxwell, 1996; Schreier, 2018). The recruitment of participants was initiated by individual emails being sent to a list of 47 community gardens in Dublin, of which seven replies were received. Subsequently four more potential locations were found, and finally six were chosen in total to take part in the research.

Focus group discussions took place at five location sites during February 2019. Local views and opinions emerged at each location, which allowed for recruiting of a total of 15 participants to participate in the study; three more participants were purposively recruited. Each participant is to interact with one of the six enclosures located at different location across Dublin, for a continuous period of three months. The total time frame allocated for data collection following all participants' interaction is between March – November 2019.

From late February until early March 2019, in-depth semi-structured interviews were conducted with the first six participants due to start their engagement March 2019. Similarly, the first set of interview questions were discussed with the second batch of the six participants, from late May until early June 2019. All interviews were audio recorded, and they are intended to reveal participants' stance in relation to various subjects, including available recycling facilities and behaviour; attitude towards sustainable practices; and upgrading to new technologies.

The first batch of six participants were interviewed for the second time, at the end of the timeframe of their participation. This took place early June 2019, and their interpretations and experiences following the three month engagement were audio recorded. Technical aspects, attitude towards technology, and psychological traits were discovered. Data collection and analysis is taking place simultaneously, and for open coding purposes gerund verbs were used in NVivo, implying action and later turning into topics (Charmaz, 2006). Alongside with reviewing of extensive analytical memos, the analysis naturally moved on from the open coding stage to focused coding, following a process of differentiation, combining and reflection on data

(Charmaz, 2006; Miles & Huberman, 1994). The qualitative data collected following focus group discussions, interviews, and observations are corroborated with the quantitative data collected following participants' interaction.

For the purpose data collection, a total of six enclosures (Figure 1) were purposely built between September 2018 – March 2019, and automation features were added – irrigation valves, windows, and ventilation fans. The enclosures are located at six different sites around Dublin as follows:

- three community gardens, free access for volunteers;
- two up-skilling centres, free, mainly for teenagers from disadvantaged backgrounds;
- one public allotment, paid-for annual membership.

Figure 1 – Enclosure located at one of the research sites. Source: Hamilton V. Niculescu

An Arduino Mega 2560 programmable board, with required accessories, represents the central controlling, processing and remote communication point at each location (Figure 2). Apart from reading the battery voltage level, air humidity, temperature, and soil moisture values and acting upon it, the Arduino board ensures outside communication with an online server through which communication with participants' mobile phone app takes place. Any changes happening from either side – the system in Automatic mode, or the participant in Manual mode – are being recorded on the online server, and can be downloaded for triangulation purposes along with the qualitative data, during the analysis process.

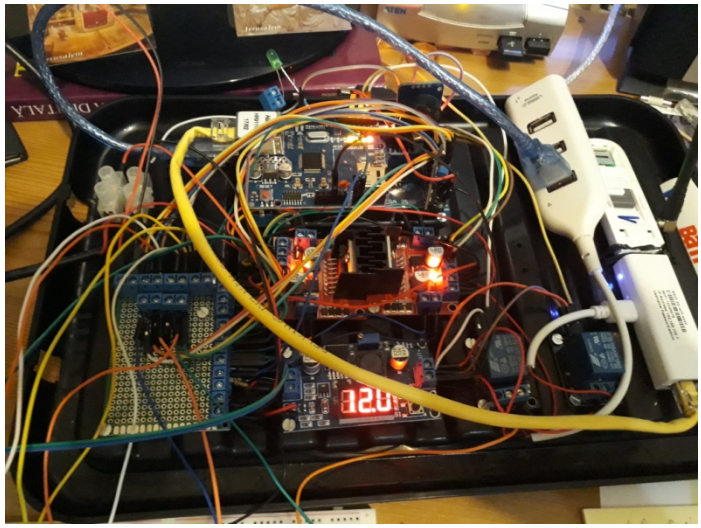

Figure 2 – Arduino Mega 2560 and electronic accessories used for communication and control. Source: Hamilton V. Niculescu

The quantitative data provides time-stamped blocks of data (Figure 3) about system's status as follows:

- system working mode (automatic/manual);
- soil moisture (percentage);
- air humidity (percentage);
- air temperature (Centigrade);
- irrigation status (on/off);
- ventilation fans status (on/off);
- windows status (open/closed).

Figure 3 – Online server acting as data depository, as well as the communication link between the phone app and automated system. Source: https://thingspeak.com

By using a custom developed mobile phone app (Figure 4) participants have control over the functionality of the enclosures. As such, according to sensor values provided, the users can:

- open/close the windows;
- start/stop the air circulating fan;
- start/stop the irrigation;
- send a log, which is paramount in qualitative research.

When the current climate conditions inside the enclosure do not match the optimal values set by the participant, colour-coded bars and in-app notifications are displayed on the phone's screen, prompting the user to take corrective measures. Apart from the need of implementing custom functionalities and settings in the app, required to connecting and controlling a particular enclosure, having developed the mobile app myself also guarantees the anonymity and privacy of participants.

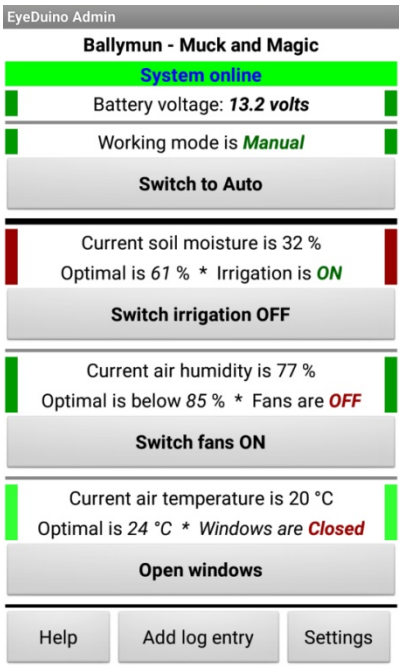

Figure 4 – The main screen of the custom developed mobile phone app. Source: Hamilton V. Niculescu

Findings

During the first interviews it became clear that all participants are aware of the fact that many materials can be recycled in order to save or produce energy. As all those involved in the study have access to community gardens, composting of organic waste does not represent a huge problem.

Mixed feelings in relation to renewable energy sources have emerged, many expressing their concerns related to reliability, price, and their negative impact on the environment. However, it became clear that participants are aware that innovative, more sustainable solutions must be developed in order to ensure their required energy for survival.

Following participants' three months interaction with the automated system, a set of thematic barriers acting against adoption of more sustainable practices surfaced during the interviews, and these will be analysed in detail in the discussion section.

Recycling of packaging and of non-organic waste

In many instances, the location of the household (urban environment) means not having access to proper recycling facilities, due to space restrictions or long distance required to travel to such recycling centres. While shopping, many are forced to carefully select products that have least packaging. In fact many participants expressed their concern in terms of the unnecessary amount of plastic packaging of the goods they are buying, being aware of the amount of money and energy being wasted both during the production and for recycling it.

'*you're actually paying for packaging, and then that goes out and... the tax payers money goes into getting rid of that packaging. Like the people who are producing it and selling it aren't paying as much as they should be to get rid of.*'
Participant #3

Some participants mentioned the problems created by plastic waste in agriculture: pots and trays, polythene covering the greenhouses, irrigation pipes – all being very difficult to recycle when in need of replacement. This is because only specific types of plastic can actually be recycled, and those types need to be sorted, and properly washed of any residues. Participants felt that more education is needed in order to make the general public more aware of energy waste and recycling.

The participants also demonstrated having knowledge about the running out fossil fuels being burned in order to produce electricity and heat. They are trying to reduce the amount of energy being wasted by setting the central heating thermostat to lower values, or by using mobile phone apps that monitor and control the heating or electricity in their household.

Experience with renewable technologies

An interesting topic that emerged during the interview was that of renewable technologies. Although many participants admitted that they are not up to date with the latest technology developments, the general consent is that renewables are expensive, not very reliable, and adding to the amount of already existing electrical waste. In the past, some participants attempted at having some combinations of such technologies installed in their household, but the high price acted as a deterrent. They have done no further investigations more recently, yet believe that these technologies are not financially worthy.

Although people would like to become more independent from the national grid, seen as unreliable, there are also mixed feelings about the reliability of the renewable energy sources, which represent another major barrier into adopting renewable technologies. People believe that they will not be able to produce as much energy as currently needed within their households. However, all participants showed an interest into switching to renewable sources, should money not be a concern, and they would see no problem to consequently changing their lifestyle. It is particularly interesting to note the extensive knowledge that one participant demonstrated in relation to renewable technologies:

'*solar isn't efficient enough, wind turbines also use heavy metals that environmentally are a disaster [...] they don't last, they take huge resources, and cost a fortune*'
Participant #4

Engaging with the mobile phone app

The ease of using the phone app allowed to confidently plant more vegetables than usual, believing that the automation features would assist them, something they would have not done before, due to lack of time required for caring for the plants during their growth cycle.

'*If it was an ordinary polytunnel, without this automation in it, I would have to physically go and check it, have a look at soil, or open the windows or the doors... it's amazing, it does it all for you.*'
Participant #2

'*I would have never had the amount of plants I have now, if it hadn't been for the fact that I knew I wouldn't have the time and I would neglect them.*'
Participant #4

However, the participants showed no remarkable signs of being aware of the fact that the automated systems were powered by PV solar panels and a battery pack, and that they should be wary of actions they take in terms of switching devices on or off. Many admitted of having no knowledge of how electricity actually works.

'*I assumed it was a new battery. And I know nothing about charging values and these things. And I assumed that you put in some fail safe measures. It says now that the voltage is 13.5V, but I don't know what it means, and whether it would take me thru the night. So is this value good?*'
Participant #4

Many participants preferred to initially set some (what they though would be) optimal values in the app, then switch the system to Automatic mode, allowing it to care for the plants by itself. During the interview many acknowledged the fact that they preferred to rely on the system to sustain itself, rather than assuming control and taking suggested actions. These decisions were also reflected in the logs that participants sent during their engagement, mostly referring to problems they have noticed with the (sometimes) non-optimal values they set in the phone app (Figure 5), without actually taking corrective measures by adjusting the related values.

'*I was more interested to see what actually the system was saying, and if it agreed with me. I know the polytunnel for seven years now, so I was looking at it and I was going like 'yeah, yeah, yeah'.*'
Participant #3

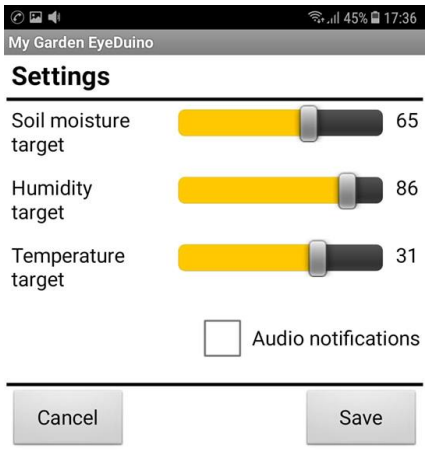

Figure 5 – Settings screen in the mobile app. Source: Hamilton V. Niculescu

However, after comparing this information against the quantitative data, it was concluded that they did not in fact use the app as often as they mentioned they did. As some participants admitted:

'*I think there should be more persons looking after it, for I kept forgetting about it.*'
Participant #6

'*I think sometimes I went into manual mode. And sometimes I forgot about it and left it like this.*'
Participant #5

Most participants manifested a big interest at the start of their engagement timeframe, showed both during their initial training and by the quantitative data, but this was played down by adverse weather conditions, which eventually led them to forgetting about the enclosure and the phone app.

'*At the start I checked it every second day. But it depends on the weather as well. If it's raining, it would be ok, for it's not too hot, the windows don't need to be open*.'
Participant #1

'*The weather was not great, which meant to leave the polytunnel on its own, because it has its own microclimate, so there wasn't much interaction [...] And I forgot the interface. If you don't use it all the time, you forget about it*.'
Participant #3

A direct connection to these statements would be lack of time being invoked for their low engagement. All six automated systems are located within 'working class' areas, and as such the demographics are characterised by participants with generally low income, and as Participant #9 mentioned, '*when people are working really hard and don't have a lot of money and that, they say 'I don't have time', they feel that they are under a lot of pressure*'. This confirms my suspicions that when participants were claiming lack of time as a reason for low interaction, in fact there are some other more subtle, underlying aspects that participants may not have been willing to reveal. During the interviews with the two deviant cases it became more clear that lack of time was not the real issue.

'*the app is interesting as a matter of fact, but I did not feel motivated to go there* [...] *If I knew that at the end of the three months I would make some money by selling the products, I would have been more motivated.*'
Participant #1

Therefore while initially some participants might have interpreted the automated system as a great tool to helping them with growing their vegetables, the prospect that this will only be available to them for a relatively short period of time could have had led them to reassessing their involvement and effort they need to put in.

'*That's why I'm amazed by it, and I'm actually in control of it. Not only that I see it working, I'm actually in control of it. Everybody is fascinated*. [...] *I'm not in control anymore, I will feel that I lost something, I got used to it. I lost control over it, and it's not nice.*'

Participant #2

Discussion

For the first two months (March and April 2019) participants' engagement was generally very low, confirmed during the interviews, as well as by quantitative data, with bad weather having a negative effect on their initial excitement. Cold weather, high winds and high air moisture meant that there was not much they could have done using the phone app in order to improve the conditions inside the enclosures. This fact may have eventually made them getting bored of seeing the same information being displayed on their phone screens, and eventually they started to 'switch off' and forget about it completely.

During initial training delivered to participants, before starting their period of interaction with the automated system, a need for 'instant gratification' was noted on peoples' part. Although they were informed that a certain amount of time has to pass between sending a command using the mobile phone app and the system actually responding to it, all participants were still expecting the system to react instantly upon using the app. This could in effect also have had acted as a deterrent towards engaging in remote communication with some physical system that was not physically in sight.

As most participants involved in this study are volunteers in the community gardens, the allocated time for their gardening tasks may not be tightly scheduled. Creating additional activities, such as engaging with the available automation technology, might act as a push in the other direction, i.e. people taking more time off from the garden and allowing the technology to look after the plants instead. Corroborating these findings with the data collected during interviews with the deviant cases, it became more clear that lack of time is in fact used as an excuse for a more subtle reason, as explained below.

During participants' recruitment process, bad weather acting as a deterrent was also mentioned by the administrator of the paid-for allotment site. An invitation email, sent by the administrator, was circulated amongst members of that place, with only one person making contact with me by email and showing an interest to participate in the study. This prompted me to find an alternative, and purposively pick two more participants of which I knew that they do not have much experience, interest and knowledge in gardening. They would represent the two negative cases in my study. Although I repeatedly emphasised the fact that they are not required to travel to the actual location, but only control it remotely using their smart phones, both of them indicated that they would not have time '*to deal with gardening stuff*' (Participant #1).

While financial revenue was mentioned as one potential motivation factor, this directly links to traits of control and ownership. Going back to data gathered from other participants, I noticed that although not directly acknowledged, knowing that their short engagement period of only three months would eventually mean losing control of the automation features, it might have had an impact in regards to their motivation to engage with the app and the system. Ownership surfaced as being a critical factor influencing engagement with sustainable automated systems, even in community gardens where one would expect people to show a better developed community spirit. Similar behaviour traits were noticed by studies looking at people

adopting technologies aimed at producing renewable energy (Chapman & Itaoka, 2018; Smith & Urpelainen, 2014; Szarka, 2007). People feeling empowered while being involved in a project, at the end of their participation may experience as losing something that allowed them to 'showing off' to their community members. In effect, arguments that technology could both bring benefits, as well as enlarging the knowledge gap for individuals and local communities, are further strengthened by these findings (Cowan R.S., 1989; Csikszentmihalyi & Rochberg-Halton, 1981; Selwyn, 2003; Silverstone, 2003; Silverstone & Hirsch, 1994).

Participants' involvement in technology development and the sense of ownership was also noticed as playing an important role in adoption of technology, by a study that was conducted in Scotland: '*being involved in the project was about enjoyment and personal achievement*' (Taylor et al., 2018). Again, referring back to the negative cases in my study, the Participant #1 has asked me to build a similar automated system for his own greenhouse. That system became functional during the last month of the participant's timeframe of engagement in my study. The sudden change in behaviour in relation to interaction with his own system strengthened my suspicion that ownership plays a vital role in people accepting new innovations.

'*with my greenhouse... it's not like yours. With yours I had no... motivation. [...] Mine. This is what motivates me. That is mine. And yours was not handy to get to.*'
Participant #1

Conclusions

As it became clear from analysing of interviews conducted during this study, recycling became naturally embedded in Irish people's behaviour. Similarly, adoption of sustainable energy sources and changes that these will bring to their lifestyles might only become successful following a long, not necessarily easy process of communication and shared development. As confirmed by similar studies, education represents an important step in the process of diffusion and adoption of innovations by local communities.

After a period of three months, and during a period of relatively low engagement of participants with the enclosures, with bad weather being blamed by most participants, some small changes in peoples' behaviour are observed in regards to their attitude towards and engagement with communication technologies involved in the study. It was learned that ownership, relative advantage and trialability are factors playing a critical role in the process of adoption of innovations, augmenting existing theory and previous studies' findings (Almlund, Jespersen, & Riis, 2012; Claudy, Garcia, & O'Driscoll, 2015; Faiers & Neame, 2006; Gobin, Cadersaib, Sahib-Kaudeer, & Khan, 2017; Nuñez Jimenez, 2015; Ozaki, 2011; Reinhardt, Hietschold, & Gurtner, 2017; Rogers, 1995; Wolske, Stern, & Dietz, 2017)

The ongoing collection of data (due to finish November 2019) may strengthen these arguments, while other themes may potentially be developed. Studies to include people from other social classes may bring new details in relation to adoption of technologies.

Limitations of this research

The inductive methods used for data interpretation, and also by using a small sample of Irish, working class population living in an urban environment, means that this study's findings may not apply for larger populations, and/or under different settings or locations, and/or under the influence of different social, economic, and cultural factors.

References

Alemu, G., Stevens, B., Ross, P., & Chandler, J. (2015). The Use of a Constructivist Grounded Theory Method to Explore the Role of Socially-Constructed Metadata (Web 2.0) Approaches. *Qualitative and Quantitative Methods in Libraries (QQML)*, *4*, 517–540. https://doi.org/10.2014/Accepted

Almlund, P., Jespersen, P. H., & Riis, S. (Eds.). (2012). *Rethinking Climate Change Education*. Surrey; Burlington: Ashgate Publishing Limited.

Augustenborg, C. A., Finnan, J., Mcbennett, L., Connolly, V., Priegnitz, U., & Müller, C. (2012). Farmers' perspectives for the development of a bioenergy industry in Ireland. *GCB Bioenergy*, *4*(5), 597–610. https://doi.org/10.1111/j.1757-1707.2011.01151.x

Benyus, J. M. (2002). *Biomimicry. Innovation inspired by nature*. New York: Harper Perennial.

Birks, M., & Mills, J. D. (2011). Grounded theory: a practical guide. Los Angeles; London; New Delhi; Singapore;Washington DC: SAGE.

Blok, V., & Gremmen, B. (2016). Ecological Innovation: Biomimicry as a New Way of Thinking and Acting Ecologically. *Journal of Agricultural and Environmental Ethics*, *29*(2), 203–217. https://doi.org/10.1007/s10806-015-9596-1

Brinkmann, S. (2013). *Qualitative Interviewing: Understanding qualitative research*. New York: Oxford University Press. https://doi.org/10.1093/acprof

Chapman, A., & Itaoka, K. (2018). Energy Research & Social Science Curiosity , economic and environmental reasoning: Public perceptions of liberalization and renewable energy transition in Japan. *Energy Research & Social Science*, *37*(August 2017), 102–110. https://doi.org/10.1016/j.erss.2017.09.026

Charmaz, K. (2006). *Constructing grounded theory: a practical guide through qualitative analysis*. *Book* (Vol. 10). London; Thousand Oaks; Delhi: SAGE Publications. https://doi.org/10.1016/j.lisr.2007.11.003

Claudy, M. C., Garcia, R., & O'Driscoll, A. (2015). Consumer resistance to innovation—a behavioral reasoning perspective. *Journal of the Academy of Marketing Science*, *43*(4), 528–544. https://doi.org/10.1007/s11747-014-0399-0

Cowan R.S. (1989). *More Work for Mother*. London: Free Associations.

Creswell, J. W. (2007). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*. *Book* (Vol. 2nd ed). London; Thousand Oaks; Delhi: SAGE Publications. https://doi.org/10.1016/j.aenj.2008.02.005

Csikszentmihalyi, M., & Rochberg-Halton, E. (1981). *The Meaning of Things: Domestic Symbols and the Self*. Cambridge: Cambridge University Press.

Davies, M. B. (2007). *Doing a Successful Research Project*. Hampshire; New York: Palgrave Macmillan.

Denzin, N. K., & Strauss, A. L. (2003). *Qualitative Analysis for Social Scientists.* Cambridge,: Cambridge University Press. https://doi.org/10.2307/2069712

Denzin, N., & Lincoln, Y. (2005). *The Sage handbook of qualitative research* (3rd ed.). Thousand Oaks, CA: SAGE.

Elzen, B., Geels, F. W., & Green, K. (Eds.). (2004). *System Innovation and the Transition to Sustainability: Theory, Evidence and Policy*. Cheltenham: Edward Elgar.

Enevoldsen, P., & Sovacool, B. K. (2016). Examining the social acceptance of wind energy: Practical guidelines for onshore wind project development in France. *Renewable and Sustainable Energy Reviews*, *53*, 178–184. https://doi.org/10.1016/j.rser.2015.08.041

Faiers, A., & Neame, C. (2006). Consumer attitudes towards domestic solar power systems. *Energy Policy*, *34*(14), 1797–1806. https://doi.org/10.1016/j.enpol.2005.01.001

Flick, U. (2011). *The SAGE handbook of qualitative data analysis*. (U. Flick, Ed.), *The SAGE Handbook*. London; Thousand Oaks; Delhi: SAGE Publications. https://doi.org/10.4135/9781446282243.n33

Flick, U. (2018). Triangulation in Data Collection. In U. Flick (Ed.), *The SAGE handbook of qualitative data collection* (pp. 527–544). London; Thousand Oaks; Delhi: SAGE Publications.

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from sociology and institutional theory. *Research Policy*, *33*, 897–920.

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, *1*(1), 24–40. https://doi.org/10.1016/j.eist.2011.02.002

Gilly, M. C., Celsi, M. W., & Schau, H. J. (2012). It Don't Come Easy: Overcoming Obstacles to Technology Use Within a Resistant Consumer Group. *Journal of Consumer Affairs*, *46*(1), 62–89. https://doi.org/10.1111/j.1745-6606.2011.01218.x

Gobin, A. B., Cadersaib, Z., Sahib-Kaudeer, N. G., & Khan, M. H.-M. (2017). Investigating Technology Awareness and Usage in Mauritian SMEs in the Handicraft Sector. *International Journal of Computer Applications*, *174*(7), 41–48. https://doi.org/10.5120/ijca2017915437

Grin, J., Rotmans, J., Schot, J., Geels, F. W., & Loorbach, D. (2010). *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change*. New York: Routledge.

Henwood, K., Shirani, F., & Groves, C. (2018). Using Photographs In Interviews. In F. Uwe (Ed.), *The SAGE handbook of qualitative data collection* (pp. 599–613). London; Thousand Oaks; Delhi: SAGE Publications.

Kennedy, B. L., & Thornberg, R. (2018). Deduction, Induction, and Abduction. In U. Flick (Ed.), *The SAGE handbook of qualitative data collection* (pp. 49–64). London; Thousand Oaks; Delhi: SAGE Publications.

Latour, B. (1993). *We Have Never Been Modern*. Harlow: Pearson.

Maxwell, J. A. (1996). *Qualitative Research Design: An Interactive Approach*. California; London; New Delhi: SAGE Publications.

Michael, M. (2000). *Reconnecting Culture, Technology and Nature: From Society to Heterogeneity*. London: Routledge.

Miles, M. B. M. B., & Huberman, A. M. M. (1994). *Qualitative Data Analysis* (2nd ed.). California; London; New Delhi: SAGE Publications.

Mills, J. E., Bonner, A., & Francis, K. (2006). Adopting a constructivist approach to grounded theory: Implications for research design. *International Journal of Nursing Practice*, *12(1)*(March), 8–13. https://doi.org/10.1111/j.1440-172X.2006.00543.x

Moore, J. W. (2010). Cheap Food & Bad Money. *Review: A Journal of the Fernand Braudel Centre*, *33*(2–3), 225–261.

Morgan, T. (2016). The techno-finance fix: A critical analysis of international and regional environmental policy documents and their implications for planning. *Progress in Planning*, (September). https://doi.org/10.1016/j.progress.2016.06.001

Nuñez Jimenez, A. (2015). Enhancing PV systems adoption by Swiss households, a system dynamics policy analysis, (January), 83. https://doi.org/10.13140/RG.2.2.28238.25925

Ozaki, R. (2011). Adopting sustainable innovation: What makes consumers sign up to green electricity? *Business Strategy and the Environment*, *20*(1), 1–17. https://doi.org/10.1002/bse.650

Pickering, M. (Ed.). (2008). *Research Methods for Cultural Studies*. Edinburgh: Edinburgh University Press Ltd.

Qureshi, T. M., Ullah, K., & Arentsen, M. J. (2017). Factors responsible for solar PV adoption at household level: A case of Lahore, Pakistan. *Renewable and Sustainable Energy Reviews*, *78*(September), 754–763. https://doi.org/10.1016/j.rser.2017.04.020

Ramirez-Portilla, A., Cagno, E., & Trianni, A. (2014). Is Innovation an enabler of Energy Efficiency? An exploratory study of the foundry sector. *Energy Procedia*, *61*, 1191–1195. https://doi.org/10.1016/j.egypro.2014.11.1051

Räthzel, N., & Uzzell, D. (2017). Environmental Policies and The Reproduction of Business as Usual: How Does It Work? *Capitalism, Nature, Socialism*, (September), 1–19. https://doi.org/10.1080/10455752.2017.1371200

Reinhardt, R., Hietschold, N., & Gurtner, S. (2017). Overcoming consumer resistance to innovations - an analysis of adoption triggers. *R and D Management*, 1–16. https://doi.org/10.1111/radm.12259

Rogers, E. M. (1995). *Diffusion of innovations* (5th ed.). New York; London: Free Press.

Saka, A. B., Olawumi, T. O., & Omoboye, A. J. (2017). Solar Photovoltaic System: A Case Study of Akure, Nigeria. *World Scientific News*, *83*(August), 15–28. Retrieved from http://www.worldscientificnews.com/wp-content/uploads/2017/07/WSN-83-2017-15-28.pdf

Sandel, M. J. (1997). It's Immoral to Buy the Right to Pollute. *New York Times*, 1.

Sarabhai, K., & Vyas, P. (2017). The leapfrogging opportunity: The role of education in sustainable development and climate change mitigation. *European Journal of Education*, *52*(4), 427–436. https://doi.org/10.1111/ejed.12243

Schreier, M. (2018). Sampling and Generalization. In U. Flick (Ed.), *The SAGE handbook of qualitative data collection* (pp. 84–98). London; Thousand Oaks; Delhi: SAGE Publications.

Selwyn, N. (2003). Apart from technology: Understanding people's non-use of information and communication technologies in everyday life. *Technology in Society*, *25*(1), 99–116. https://doi.org/10.1016/S0160-791X(02)00062-3

Silverstone, R. (2003). Media and Technology in the Everyday Life of European Societies Everyday Life Network, 2000-2003. *Political Science*, (September), 2000–2003.

Silverstone, R. (2005). *Media, technology and everyday life in Europe: From information to communication*. Aldershot, Hants, England; Burlington, VT: Ashgate Publishing Company.

Silverstone, R., & Hirsch, E. (Eds.). (1994). *Consuming Technologies. Media and Information in Domestic Spaces*. London, New York: Routledge. https://doi.org/10.4324/9780203401491

Smith, M. G., & Urpelainen, J. (2014). Early Adopters of Solar Panels in Developing Countries: Evidence from Tanzania. *Review of Policy Research*, *31*(1), 17–37. https://doi.org/10.1111/ropr.12061

Strauss, A. L., & Corbin, J. (1994). Grounded theory methodology: An overview. In N.K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 273–285). Thousand Oaks, CA: SAGE.

Szarka, J. (2007). Why is there no wind rush in France? *European Environment*, *17*(5), 321–333. https://doi.org/10.1002/eet.460

Taylor, N., Clarke, L., Skelly, M., & Nevay, S. (2018). Strategies for Engaging Communities in Creating Physical Civic Technologies, (April), 1–12. https://doi.org/10.1145/3173574.3174081

Vasseur, V., & Kemp, R. (2015). The adoption of PV in the Netherlands: A statistical analysis of adoption factors. *Renewable and Sustainable Energy Reviews*, *41*, 483–494. https://doi.org/10.1016/J.RSER.2014.08.020

Wolske, K. S., Stern, P. C., & Dietz, T. (2017). Explaining interest in adopting residential solar photovoltaic systems in the United States: Toward an integration of behavioral theories. *Energy Research and Social Science*, *25*, 134–151. https://doi.org/10.1016/j.erss.2016.12.023

Contact email: viorel.niculescu2@mail.dcu.ie

Land Administration and Sustainability in Nigeria: A Rethink?

Nyingi Bonnie, University of Aberdeen, Scotland

The European Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
Land constitutes a very important medium. This is simply because all of humanity dwells on it and depend on it for survival. But one factor responsible for the misuse of land is misconception. This misconception flows from the value attached to land. Helena Howe argues that there are two dominant perspectives with regards to land or the value attached to land. These are anthropocentric and ecocentric approaches. The anthropocentric approach is interest-centred. It centres on who benefits from the land. On the other hand, an ecocentric approach is centred on relationship with land that entails close ties with land embodying even spiritual implications. She also argues that laws, regulations and environmental decisions that flow from it are centred on the benefit that can be derived from land without reference to its intrinsic value. Land is seen as a commodity not as part of the wider earth community. To ensure good management practices of land use requires a rethink of the relationship with land so that laws, regulations and environmental decisions that flow from it will reflect this relationship. This Paper will draw on traditional African conception of land as embodying an ecocentric framework. It will discuss the legal principle of harmony with nature with practical examples. In traditional African jurisprudence, land was regarded as a deity. It was not commoditised, it was their identity. This changed with modernisation. Laws that do not reflect this connection evidently disconnects with the people and has been a cause of crises in Nigeria's oil region.

Keywords: Anthropocentric, ecocentric, misconception

iafor
The International Academic Forum
www.iafor.org

Introduction

"Land is always there: under our noses, beneath our feet, and perhaps even in our souls" (McFarlane, Hopkins & Neild, 2015, p.3). It is regarded as something of a national obsession in the United Kingdom (McFarlane, Hopkins & Neild, 2015). There are so many interests in land, the State, individuals and organisations. But what about the interest of the land itself? The question is 'Quo Bono?' (latin expression which means 'in whose interest?'). Land is more than mere resource. When meaning is added to it, it takes on very different dimension. It is symbolic. The relationship between land and people is said to be the template for society and social relations (Graham, 2008). A major handicap with most of the Laws churned out in Nigeria stems in part from the failure to take into account culture, including customary practices and lived experiences otherwise known as the 'living Law'. This creates a disconnect between the Law and the people. This disconnection creates a situation of 'sterile dualism' which reflects tension between State Law and non-State Law such as Customary Law. Onibon, Dabire and Ferroukhi (as cited in Benjamin C, 2008). Sterile dualism is the coexistence of impracticable State Law and unauthorised local practices. Onibon, Dabire and Ferroukhi (as cited in Benjamin C, 2008). As Charles Benjamin puts it; '[t]he State promulgates Laws that are not compatible with local livelihood patterns and practices, while simultaneously rendering many of those practices illegal'. (Benjamin C, 2008). Customary Law is a contentious subject. This is in part due to the position of earlier scholars who did not regard Customary Law as Law but mere custom. So, their investigation of Customary Law was limited to dispute resolution which they studied as a feature of society (Woodman G, 1998). They did not investigate the 'living Law'. However, 'living Law' continues to regulate community life though unrecognised by the State. The (Land Use Act 1978, 2004) is one of such legislations that clearly disconnects with the people.

Development of the (Land Use Act 1978, 2004)

The (Land Use Act 1978, 2004) is the principal legislation for land administration in Nigeria. Prior to the Act, there were different systems of landholding in Nigeria (Mabogunje A, 2007). Lagos had a freehold system established by the colonial authorites after its annexation in 1861 (Mabogunje A, 2007). The North operated Maliki Law which automatically conferred on the colonial authorities rights to and control of their lands (Mabogunje A, 2007). A Committee was set up in 1908 to determine the nature of the land tenure system in Northern Nigeria (Nwocha M, 2016). The Land Proclamation Act of 1910 was passed as a result and it was replaced by the Lands and Native Rights Ordinance of 1916 (Nwocha M, 2016). The North also had a Land Tenure Law in 1962 (Nwocha M, 2016). What in effect the Land Use Act did was to bring into operation the Land Law operating in Northern Nigeria to the rest of the country (Mabogunje A, 2007). Meanwhile the land tenure system in the Southern part of the country was totally different from the North (Mabogunje A, 2007). Land belonged to the community, village or family. The Act clearly alienated the people from their lands. This very act has been described as an abrogation of their rights to their lands (Mabogunje A, 2007). This is even more so because oil operations are carried out on community lands without consent and consultation as the Act does not provide for consent. In terms of payment of compensation, consideration is given to economic crops but not to crops with cultural significance (Wilson A, 2005). There is no payment of compensation for the acquisition of land

for public purposes where such land is not developed. Although the Act provides for the payment of adequate compensation, it does not define in actual terms what adequate compensation means. In any case, since these lands are State lands, these oil companies do not have to pay compensation but in actual practice, they do. However, before the Act, communities dealt directly with these companies with monies paid directly to them (Wilson A, 2005). These payments were in the form of decennial leases but this was no longer the case after the Act (Wilson A, 2005). Oil no doubt is the mainstay of the Nigerian economy but this state of affairs has prompted agitations and calls for control of resources in community lands. Resolving this impasse requires a rethink of the relationship with land. Helena Howe argues that "connection with nature-and specifically, with land-underpins any transformation of property law from an anthropocentric, individualist concept to a more ecocentric and relational one" (Howe H, 2017). What does land mean to these communities? In traditional African jurisprudence, land was regarded as a deity. It was not sold, it was communally owned. It was their identity, their heritage. Due to this prevailing belief and practice at the time, the Colonial Office set up a Lands Committee to investigate the land tenure system in all its West African colonies in 1912 (Mabogunje A, 2007). Land sale started as colonialism progressed (Mabogunje A, 2007).

Harmony with nature

This head examines in the pre-colonial era, relationships of some communities with land. A survey of some Ijaw communities in the Niger Delta region will reveal close ties with land, harmony with nature. Harmony with nature is a legal principle of Customary Law (Brendan T, 2014). It is embedded in Customary Law principles (Brendan T, 2014). Brendan Tobin argues that the normative quality of Customary Law rests in the principles it enshrines and not in any specific rules (Brendan T, 2014).

Ijaw is the most important tribe in the lower Delta, and indeed, after the Ibo, in the whole of Southern Nigeria (Alagoa E, 1995). Among the Igbomoturu-West Bumo, a community in Bayelsa State which is part of the Niger Delta region, the earth was considered as an object of worship, a deity and was sacred to them (Ibegi C, 2003). The importance of the earth to them lies in the belief that all food and vegetation are derived from it and it is believed to be God's footstool (Ibegi C, 2003). The earth was invoked for judgement against a claim (Ibegi C, 2003). As a deity, there were sessions involving libation, prayers and sacrifices and the earth was consulted as an oracle at a place called "Amakiri" to find solutions to problems affecting the community (Ibegi C, 2003). God is known as "Woyein" which means "our Mother" (Ibegi C, 2003). As mother of all, God is believed to be the head and owner of all things in the universe (Ibegi C, 2003). The Igbomoturu people also believed in totems and this included animals such as crocodile, python, eagle and fishes. Trees also constituted totems (Ibegi C, 2003). Totems belonged to individual families and are believed to have sacred, special and cordial relationship with human beings especially families that have them (Ibegi C, 2003). A totem was regarded as a spiritual member of the human family, a covenant relationship where the human family neither ate nor harmed the totem and the totem likewise protected the human family (Ibegi C, 2003). As such, the death of a totem was an occasion for mourning. Some families went as far as giving totems token burial rites (Ibegi C, 2003). Totems were also regarded as guardian spirits and they were invoked for protection (Ibegi C, 2003). Totems were

not shared by different family groups unless where such family groups had historical or spiritual links (Ibegi C, 2003). Such totems if they were animals or fish could be eaten by those who did not have them as their totems. The crocodile was said to be a totem for the kalangakiri (a community in Bumo West) people who neither ate nor killed crocodiles (Ibegi C, 2003). People from other sections of the community hunted them for meals and this was applicable to animals such as the cat, eagle and other animals (Ibegi C, 2003). A Chief, John Kalaingo speaks of the origin of totem as dating back to inter-tribal wars:

Those who fought in these wars used these creatures to prepare charms, which they used in strengthening themselves against their enemies, …the crocodile and the eagle were animals for war. Some, however, were used for the treatment of certain diseases like smallpox …The medicine men who prepared these concoctions and war charms for them instructed them neither to kill nor eat these animals used for this purpose throughout the rest of their life (Ibegi C, 2003, p.186).

Gbarain Kingdom is another community in Bayelsa State. Gbarain is referred to as a Kingdom because it consists of many communities. It has been noted that in pre-colonial era, Gbarain's Government, religion, justice and political administration were bound together and inseparable (Tuaweri J, 2008). They also believed in ancestors as the Laws and customs were believed to be handed down by ancestors who served as watch-dogs from the 'great beyond' (Tuaweri J, 2008). The ancestors were referred to as 'Kiriyai' and played a key role in the Government of Gbarain Kingdom (Tuaweri J, 2008). As part of its system of administration, the Council of Elders were regarded as the mouth piece of the ancestors (Tuaweri J, 2008). The Council of Elders made decisions but the Executive functions were carried out by different age grades ranging from twenty-one to forty years of age (Tuaweri J, 2008). The different age grades took instructions from the Council of Elders. Although the Council of Elders was not a formal Law-making body, they promulgated Laws when the need arose and this was given divine sanction by a sacrifice to the gods of the earth and the ancestors (Tuaweri J, 2008). The earth was also invoked for judgement against a claim (Tuaweri J, 2008). There was also a Town Assembly known as "Ama Ugula" presided by a President known as "Amaksowei" (Town elder) (Tuaweri J, 2008). The President worked with an Executive to resolve disputes (Tuaweri J, 2008). The Town Assembly served as the judicial arm of Government where disputes were tried and judgement given or settled. Violation of norms was regarded not as an offence against the community but against the gods and ancestors (Tuaweri J, 2008).

Among the Nembe ethnic group in Bayelsa State, the earth was also considered as an object of worship. Ebiegberi Alagoa notes that the world-view of some Niger Delta communities is basically historical and that their systems of belief contain within them entities conceived in historical terms as the "ground" on which the identity of the community is established and that "[t]his earth is, a common object of worship or veneration among African peoples" (Alagoa E, 2006, p.21). He also notes that in the Niger Delta, the earth-spirit resides specifically in the "settled earth" – "Amakiri" (ama=city, kiri=earth) (Alagoa E, 2006). It is the spirit of the earth on which the city is founded that is venerated, not earth in general. "City-earth", he notes is a historical entity bound up with the foundation and fortunes of the community in a "continuing relationship" (Alagoa E, 2006).

This principle of harmony with nature is also found in other parts of the country. Among the Yoruba, a tribe in western Nigeria, some sustainable environmental practices involved the prohibition of felling of trees in some restricted areas. Amokaye Oludayo notes that traditional people lived in harmony with nature, ensuring a balance between themselves and the environment (Oludayo A, 2004). He notes that, to the traditional people, environment and particularly land is the essence of human self-definition, economic and cultural survival (Oludayo A, 2004). And that land as a specie of the environment is, therefore, not to be abused or degraded, but a material element to be cherished, preserved and responsibly enjoyed by the present and future generations (Oludayo A, 2004). A Nigerian Chief in the early twentieth century is noted to have once stated, *"*I believe that land belongs to a vast family of which many are dead, few are living and countless members are still unborn" (Colson E, 1971). Elizabeth Colson (1971) notes that this is perhaps the most famous and certainly most quoted statement in the literature on African land tenure. She notes further that this statement has been quoted, commented upon and treated as though it were a legal maxim underlying all systems of land holding in every part of Africa (Colson E, 1971).

Amokaye Oludayo also notes that traditional people maintained sustainable environmental practices for forestry and wildlife management which promoted biodiversity of plants and animals (Oludayo A, 2004). They classified and zoned their landmass into thick and lower forests and groves (Oludayo A, 2004). The lower forests were used for farming, housing and social needs (Oludayo A, 2004). The thick forests were not cultivated or utilised for any economic purposes (Oludayo A, 2004). They were used as medicinal plants and herbs (Oludayo A, 2004). So, since the thick forests were uncultivated, deforestation was alien to them (Oludayo A, 2004).

An interesting practice by the Yorubas, is their concept of forest reservations. There were various categories of forest reservations. Some forests were reserved for game hunting (Oludayo A, 2004). Some others were subdivided into special categories such as elephant forests and buffalo forests (Oludayo A, 2004). Hunters looking for a wild animal would go to the specialised forests to hunt for them (Oludayo A, 2004). Biological diversity was preserved where plants and animal species and inanimate objects were considered sacred (Oludayo A, 2004). They remain untouched and if tampered with, constitutes a taboo (forbidden) with penal consequences (Oludayo A, 2004). The biological diversity in such areas is said to remain safe, and to a large extent has thrived (Oludayo A, 2004). In some cases, where cultivation takes place, people preserve in-situ useful species of plants either as individual plants or in clusters of whole groves (Oludayo A, 2004). Trees that are considered to have spiritual values are regarded as sacred which serve as habitats for the spirits and gods and must never be cut except directed by the gods such as the iroko tree (Oludayo A, 2004). Such trees were never cut nor cleared in the lowlands, except on very rare occasions or when such trees were needed for housing and social purposes such as construction of local bridges, palaces, shrines and social centres (Oludayo A, 2004). This practice preserved thick forests which ultimately provided useful defence against adversaries in time of war in ancient period (Oludayo A, 2004). The conservation of biodiversity in-situ is further achieved through preservation of different kinds of protected areas such as parks, natural reserves, wildlife sanctuaries and biosphere reserves (Oludayo A, 2004).

The practice in Ijebu communities (also in western Nigeria) with sedimentary soils, their Customary Laws encouraged them to engage in tree planting exercises and this helped to stem erosion. Adewale (as cited in Usman A, 2017). The Osun-Osogbo Sacred Grove, now a World Heritage Site is a product of these sustainable practices (Mechtild Rossler, 2006). It is interesting to note that Cameroon has adopted zoning arrangement in its forest management. It operates a decentralised regime in forestry management and wildlife protection based on customary practices. Some lands are under Government control and others under the control of communities with profit or benefit sharing arrangements and in accordance with the National Environmental Management Plan (Galega P, 2018). The 1994 Forest Law makes this arrangement possible (Galega P, 2018). The forest is zoned into Permanent Forest Estate (PFE) and Non-Permanent Forest Estate (NPFE) (Galega P, 2018). The Permanent Forest Estate establishes permanent forest domain under State ownership and Local Council ownership (Galega P, 2018). These are for forestry purposes, the creation of protected areas and research (Galega P, 2018). The Non-Permanent Forest Estate consists of forests for uses other than forestry and for private forest estates by individuals, corporate entities, forest estates allocated for community forest management and residual Local Council forest estates (Galega P, 2018). Community Forestry is an innovation in Cameroon with local communities able to participate in forest management using their traditional knowledge and practices which are sustainable (Galega P, 2018). The Forest Law also makes it mandatory to produce management plans for each Forest Management Unit (FMU) granted to logging companies (Galega P, 2018). This is to ensure that their activities are in line with the Forest Management Plan (Galega P, 2018). The Forest Law as noted earlier, provides for a profit or benefit sharing arrangement. These are annual forest royalties paid by logging companies. The annual forest royalty scheme provides for 50% to the State, 40% to the Local Council and 10% to the local community from total forest revenue (Galega P, 2018). There are also provisions for determining the basis and methods of collecting royalty and taxes on forestry activities, establishing Management Committees responsible for managing forest royalties, and modalities for monitoring the use of the revenue (Galega P, 2018).

Equally notable in Cameroon is the arrangement on wildlife protection. A classification arrangement is in place with species grouped as ‘A, B and C’ (Galega P, 2018). Rare species threatened with extinction are grouped in class A (Galega P, 2018). These are granted total protection and prohibited from being hunted except for authorised capture for research or protection (Galega P, 2018). Class A species consists of species in Annex 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Galega P, 2018)). Class B consists of species in Annex II of CITES (Galega P, 2018). Class B species are partially protected and require hunting authorisations and licences (Galega P, 2018). Class C consists of species in Annex III of CITES (Galega P, 2018). Species under this category are protected through regulated capture and hunting (Galega P, 2018). Some species require authorisation for killing and sports hunting (Galega P, 2018). Hunting permits have also been introduced by the Law (Galega P, 2018). These permits are categorised into three; those for traditional or subsistence hunting, sporting and commercial hunting. Community Hunting Ground (CHG) have been allocated by the State under the Non-Permanent Forest Estate to local communities (Galega P, 2018). Quota from hunting fees is paid to community hunting areas through Local Management Committees (Galega P, 2018).

Although Cameroon has made remarkable progress with these innovations, rights to use resources does not confer ownership of land and the resources on these communities (Galega P, 2018). The Forest Law recognises customary rights of local communities "to exploit all forest, wildlife and fish products, with the exception of protected species, for their personal use', however, these rights may be "temporarily or permanently suspended when the need arises for reasons of public interest" (Galega P, 2018, p.440). Section 7 of the Forest Law provides that; "the State, local councils, village communities and private individuals may exercise on their forest and aqualcultual establishmnets all the rights that result from ownership". These rights are subject to restrictions laid down in the regulations governing land tenure, State lands and the Forestry Law (Galega P, 2018).

Mali is another example of a decentrallised regime. It has been described as a "successful example of West African decentralization... though it shares many challenges with other developing countries-including reconciling customary and "modern" legal orders" (Benjamin C, 2008, p. 2257). Community institutions are still vibrant in Mali (Benjamin C, 2008). It has recognised customary practices in forest management but there appears to be difficulties in implementation arising from legal pluralism (Benjamin C, 2008). The Local Government is responsible for forestry management but there are some powers which are required to be transferred to the communes but it is yet to do so (Benjamin C, 2008) Where the local communities have self-organised by placing restrictions and fines, these are overturned by the Courts as the 'living Law' is not recognised as Law (Benjamin C, 2008). Charles Benjamin in a field study of three communities in Mali; Badiari, Douma and Senore, found the most successful attempt at decentralisation was with a non-governmental organisation (Benjamin C, 2008). The villages constituted an informal association to discuss preparation of a Convention (Benjamin C, 2008). The NGO was able to bring in all the stakeholders, State technical agents (forestry and agricultural extension officers), representatives of ten local communities, elected officials of the commune and reached a written Agreement based on their Customary Law (Benjamin C, 2008). The Agreement took into consideration reciprocal rights of communities especially those without forest who engaged in a process of exchange of other resources such as fisheries or flood pasture (Benjamin C, 2008). But forest management is based on formal management plans with the Forest Service overseeing their preparation. As a result of this Agreement ten important forests have been closed to all cutting and leaf harvesting for an initial five-year period (Benjamin C, 2008). The Agreement maintains customary practices such as the right of the water shaman (who coordinates water management system) to control opening and closing dates of collective fisheries, places key breeding grounds off limits to all fishing and bans some fishing techniques (Benjamin C, 2008). Flood pastures on the other hand are zoned for local herding, fee-based grazing, and commercial cutting (Benjamin C, 2008). More so, the Pastoral Charter gives authority over flood pastures to the communes (Benjamin C, 2008). The village association however, recognises the role of village Chiefs in controlling access and managing revenues on behalf of their communities (Benjamin C, 2008). In Ghana, land is managed by Chiefs (Abdulai R, 2011). These powers are open to abuse so adequate checks must necessarily be put in place to avoid rent capture by traditional authorities (Schoneveld G, 2017).

(Land Use Act 1978, 2004): Examination of some of its provisions

The (Land Use Act 1978, 2004) is not regarded as an environmental legislation but it is the legislation governing land use in Nigeria. It is the legal framework for land use and administration in Nigeria. Land administration includes land tenure (securing and transferring rights in land and natural resources), land value, land use and land development (Enemark, Hvingel & Galland, 2014). The Land Use Act was enacted to provide a uniform system of landholding in Nigeria, address land speculation issues, ensure security of tenure and to make land available to Government for developmental purposes. The Act has 8 parts and 52 sections. The Act provides for control of land which is vested in the Governor of a State. The Governor of each State in Nigeria by section 1 of the Act, holds land in trust for the use and benefit of all Nigerians. Nigeria has 36 States and a Federal Capital Territory. The Act in its long title excludes from its purview, lands vested in the Federal Government or its agencies. In section 2, lands in urban areas shall be under the management and control of the Governor of a State. Non-urban lands, that is, land in rural areas are under the management and control of a Local Government. The Act provides for leasehold interests. These are in the form of statutory and customary rights of occupancy provided in sections 5 and 6 of the Act. These are very limited interest as the Act does not give a definite time frame for these interests in land. But in practice, it is 99 years. The Act does not provide an option for renewal. These rights are subject to overriding public interest. They can be revoked for public use. There are concerns however, that the Governor's right of revocation can be subject to abuse. The Act provides for a Land Use Allocation Committee at the State level and at the Local Government level, a Land Advisory Committee. These Committees are however not functional in most States in Nigeria.

A major problem with the land administration system in Nigeria is that most lands are not registered. Apart from the cost involved, the procedure is very cumbersome due to bureaucratic bottle necks. It takes time to obtain Certificates of title. Even for assignment of leases, the requirement of consent from the Governor also takes time. These affects businesses where land is to be used as collateral to obtain loans from Banks. A 2017 World Bank Report on ease of registration amongst selected countries ranks Nigeria as 179 on the table with about 11 (11.3) procedures and about 2 months (68.9) to register title. World Bank (as cited in Oluwatayo I, Timothy O & Ojo A, 2019). Registration of title is important for the planning process. How can there be well informed plans without data? Lack of adequate planning arrangements leads to the spread of informal settlements such as slums which puts pressure on already existing inadequate infrastructure (Oluwatayo I, Timothy O & Ojo A, 2019). To aid the process of registration, suggestions have been made for a Land Administration Domain Model (LADM). The LADM is an international standard that provides a network of information between and across countries (Lemmen C, Oosterom P, & Bennett R, 2015). Some writers are of the view that customary lands should be registered (Oludayo A, 2011). Local institutions can be used in the registration process to reduce the cost of registration (Cotula, Toulmin & Hesse, 2004). Charles Benjamin however argues that "reconciling legal pluralism is not a matter of authorizing communities to continue organizing along traditional lines or of codifying customary land tenure as private property rights" but that that there should be policy framework for implementation (Benjamin C, 2008).

The tenor of the (Land Use Act 1978, 2004) is very much like a Decree. This is no surprise because the Act was originally passed as a Decree. Some of its provisions are like a tingle in the ear. Section 47 oust the jurisdiction of Courts to hear matters relating to the vesting of land in the Governor of a State. The section equally ousts the jurisdiction of Courts to hear matters relating to the right of the Governor of a State to grant a statutory right of occupancy and to the right of a Local Government to grant a customary right of occupancy. The Court is equally precluded from determining matters as to the amount or adequacy of compensation paid or payable. However, by section 29(2) where a Statutory right of occupancy is revoked for overriding public interest such as for mining or oil pipelines, the holder and occupier of such lands shall be entitled to compensation under the 'Minerals Act or the Mineral Oils Act or any legislation replacing same'. But Fenine Fekumo argues that the Minerals Act and Mineral Oils Act excludes from their purview the Land Use Act. Feninie Fekumo (as cited in Oludayo A, 2011). By section 34 (2) owners of developed plots of land prior to the commencement of the Act continue to be holders of such plots of land and are considered to be holders of Statutory rights of occupancy. All that is required is an application to the State Governor by such holders for a Statutory right of occupancy. And customary landholding continues by section 36 of the Act. On the other hand where the land is undeveloped, by section 34 (5) (a) the holder shall be entitled to only "one plot or portion of the land not exceeding half hectare". Rights to the excess land shall be extinguished and the excess land shall be taken over by the Governor. Other sections that are of concern with calls for amendment are sections 8, 22, 28 and 29. Section 8 provides for the grant of a Statutory right of occupancy for a 'definite term' and as already noted no time frame is provided but in practice it is 99 years. Suggestions have been made that the grant of a Statutory right of occupancy should be made permanent. For section 22, the requirement of Governor's consent in obtaining Certificates of title should be removed (Nwocha M, 2016). For section 28, the grounds upon which a Governor can exercise his right to revoke a Statutory or Customary right of occupancy for overriding public interest should be limited. Such grounds should not include alienation by a landowner of his interest in land (Nwocha M, 2016). And for section 29, compensation should be commensurate with the market value of the land (Nwocha M, 2016). But the requirement for amendment is stringent. It requires a constitutional amendment of two-third majority of the votes in the National Assembly and two-third majority of the votes of the Houses of Assembly in each State of the Federation. The Act is embedded in the 1999 Constitution. By section 315 of the Constitution, all existing Laws are considered to be already passed by the National Assembly. And this includes the (Land Use Act 1978, 2004) amongst the list of Laws.

Equally of note are proposals for reforms. A Technical Committee was set up in 2009 to propose reforms on land tenure. The Committee recommended the establishment of a Lands Commission. A decade later, this is yet to take effect. The Land Tenure Matters and Natural Boundaries Committee was set up in 2014. The Committee recommended that the (Land Use Act 1978, 2004) be expunged from the Constitution, The Committee also recommended the establishment of a National Land Commission. There is a clear need for amendment of the (Land Use Act, 2004).

In decentralised regimes, the approach is by devolving land and administration powers to customary institutions. Examples are Land Boards or Land Commissions, Local Government institutions such as Village Councils and Customary authorities

(Cotula L, Toulmin C & Hesse C, 2004). Madumere Nelson proposes a structural framework for land administration in Nigeria (Nelson M, 2019). This includes a National Land and Natural Resources Management and Administrative Authority at the Centre with zonal authorities at the State and Local Government level and Customary land authorities at the community level (Nelson M, 2019). Nigeria can learn from Ghana through use of customary institutions such as Chiefs in land management if it is to decentralise since most lands are in rural areas which are still governed by customary tenure instead of the ceremonial roles they currently hold. Chiefs are regarded as custodians of customs and tradition.

Conclusion and Recommendation

This Paper argues for a rethink of the land administration system in Nigeria. It argues that part of the problem with the Laws passed in the country is that these Laws do not take account of culture which includes customary practices, which in turn leads to the disconnect between Law and the people. It analyses the (Land Use Act 1978, 2004) as one of such legislations that reflects this disconnection and is a cause of crises in the Niger Delta region. It advocates for a shift in value based on Customary Law. As can be seen from the examples of some customary practices in some communities in Nigeria, this shift in value is to an ecocentric approach which is holistic and promotes sustainability. It encompasses culture, environment and economic considerations (it is profitable). Just like Ghana and other decentralised regimes, Chiefs can be incorporated in land administration process. Nigeria can learn from Ghana and other decentralised regimes in a move towards an ecocentric approach by building strong and enduring institutions based on customary Law.

Acknowledgement

My deep thanks to the University of Aberdeen Law School for the opportunity to be at the ECSEE Conference 2019 and Dr. Elias Courson for his useful insights.

References

Alagoa, E. (2006). *The practice of history in Africa: A history of African historiography*. Port Harcourt, Nigeria: Onyoma Research.

Benjamin, C. (2008). Legal pluralism and decentralization: Natural resource management in Mali. *World Development*, *36*(11), 2255-2276.doi:10.1016/j.worlddev.2008.03.005

Colson, E. (1971). The impact of the colonial period on the definition of land rights. In Turner, V. (Ed.), *Colonialism in Africa 1879-1960* (p 203), Cambridge, United Kingdom: Cambridge University Press.

Constitution of the Federal Republic of Nigeria (1999). Retrieved from https://publicofficialsfinancialdisclosure.worldbank.org/sites/fdi/files/assets/law-li

Cotula, l., Toulmin, C., & Hesse, C. (2004) Land tenure and administration in Africa: Lessons of experience and emerging issues. Prepared for the CUREMIS II programme of the Food and Agricultural Organisation by the International Institute for Environment and Development, London, England. Retrieved from https://pubs.iied.org/930IIED

Enemark, S., Hvingel, L., & Galland, D. (2014) Land administration, planning and human rights. *Planning Theory, 13*(4), 331-348.doi:10.11771473095213517882

Forest Code 1994 (January 20). Retrieved from https://sherloc.unodc.org/res/dd/document/law-no-94-01-of-20-january-1994-to-lay-down-forestry

Galega, P. (2018). A paradigm shift in the legal protection of biodiversity in Cameroon. In R. Oliver & Y. Emmanuel (Eds.), *Environmental Law and Policy in Cameroon – Towards Making Africa the Tree of Life* (1st ed., pp. 433-461). Baden-Baden, Germany: Nomos Verlagsgesellschaft mbH.

Graham, M. (2008). Some thoughts about the philosophical underpinnings of aboriginal worldviews. *Australian Humanities Review*, (45), 181 -191. http://doi.org/10.22459/AHR.45.2008

Howe, H. (2017), Making wild law work -The role of 'Connection with Nature' and education in developing an ecocentric property law: *Journal of Environmental Law*, *29*(1), 19-45.doi:10.1093/jel/eqw029

Ibegi, C. (2003) *Igbomoturu: The west bumo community* (1st ed.). Port Harcourt, Nigeria: Minson

Land Use Act 1978. (2004). Retrieved from www.nigeria-law.org/Land Use Act.htm

Lemmen, C., Oosterom P., & Bennett, R. (2015) The land administration domain model. *Land Use Policy*, *49,* 535 – 545.https://doi.10.1016/j.landusepol.2015.01.014

Mabogunje, A. (2007), Land reform in Nigeria: Progress, problems & prospects. Paper by Chairman, Presidential Technical Committee for Land Reform. Retrieved from siteresources.worldbank.org/EXTARD/Resources/336681-1236436879081/5893311-1271205116054/mabogunje.pdf

McFarlane, B., Hopkins, N., & Nield S. (2018). *Land law: Text, cases, and materials* (4th ed.). Oxford, United Kingdom: Oxford University Press.

Nelson, M. (2019). Dynamics in Nigerian land administration system and the inevitability of decentralization. Paper presented at the Thirteenth Research Association for Interdisciplinary Studies Conference on Social Sciences and Humanities, Rockville, MD, United States of America. Retrieved from rais.education/wpcontent/uploads/2019/07/Proceedings-of-the-13th-RAIS-Conference.pdf

Nwocha, M. (2016) Impact of the Nigerian Land Use Act on economic development in the country. *Acta Universitatis Danubius Administratio*, *8*(2), 117-128.journal.univ-danubius.ro/index.php/administratio/article/view/3976/3876

Oludayo, A. (2004) *Environmental law and practice in Nigeria* (1st ed.). Lagos: University of Lagos Press.

Oludayo, A. (2011) The impact of the Land Use Act upon land rights in Nigeria. In In H. Robert (Ed.), *Local Case Studies in African Land Law* (59-78), Pretoria, South Africa: Pretoria University Law Press.

Oluwatayo, I., Timothy, O., & Ojo A. (2019) Land acquisition and use in Nigeria: Implications for sustainable food and livelihood security. In L. Lius (Ed.), *Land Use – Assessing the Past, Envisioning the Future* (pp. 91 – 110), London, United Kingdom: IntechOpen.

Rosler, M., (2006) World heritage cultural landscapes: A UNESCO flagship programme 1992-2006. *Landscape Research*, *31*(4), 333-353.https://doi.org/10.1080/01426390601004210

Schoneveld, G., (2017) Host country governance and the African land rush:7 reasons why large-scale farmland investments fail to contribute to sustainable development. *Geoforum*, *83*, 119-132.https://doi.org/10.1016/j.geoforum.2016.12.007

Tobin, B. (2014*). Indigenous peoples, customary law and human rights: Why living law matters* (1st ed.), London, United Kingdom: Routledge.

Tuaweri, J. (2008). *A brief history of Gbarain Kingdom 1870-2006*. Yenagoa, Nigeria: JohnArk John.

Usman, A. (2017). *Environmental protection law and practice* (2nd ed.), Lagos, Nigeria: Malthouse Press.

Wilson, A. (2005). Oil, people and the environment: Understanding land-related controversies in Nigeria's oil region. Paper presented at the Council for Development

of Social Science Research in Africa Conference, Maputo, Mozambique. Retrieved from https://www.codesria.org/IMG/pdf/akpan.pdf

Woodman, G. (1998). Ideological combat and social observation. *Journal of Legal Pluralism and Unofficial Law, 30*(42), 21-59.https://doi.org/10.1080/07329113.1998.10756513

Does South Korea's Exporting Success Conflict with its Paris Agreement Goals of Reducing Greenhouse Gas Emissions by 37%?

Rachel Lee, Yongsan International School of Seoul, Republic of Korea
Douglas Klein, New Jersey City University, United States

The European Conference on Sustainability, Energy & the Environment 2019
Official Conference Proceedings

Abstract
South Korea is one of the most polluted countries in the world - in 2016, Korea had 76 days with bad air quality and only 45 days with good air quality. Medical studies conclude that polluted air can cause serious health problems such as stroke, heart disease, lung cancer and other ailments. Particulate matter floating in the air smaller than 10 micrometers profoundly threatens children and asthmatics and can be easily absorbed into the bloodstream of adults. The Republic of Korea or ROK is a signatory to the Paris Agreement, which aims to reduce greenhouse gas emissions below the current Business As Usual (BAU) emissions 37% by 2030. The ROK Ministry of Environment currently oversees Korea's pollution monitoring and regulations; however, attaining the Paris Agreement goals may be difficult considering the nature of Korea's export-oriented economy. The ROK is the 5th largest exporter of goods in the world - the resulting success and trade surplus has significantly increased per capita income and improved standards of living. An atmospheric test using measuring equipment provided by NASA found that half of the air pollution in Korea originates from industry, power generation, buildings and transportation vehicles. The fact that the majority of South Korea's air pollution comes from within makes proactive solutions possible. This paper will investigate the path forward examining how industrial contributors to air pollution in Korea will work with NGO actors, environmental experts and government officials to achieve the ambitious Paris Agreement goals.

Keywords: South Korea Air Pollution, Particulate Matter Harm, Paris Agreement signatories – South Korea, Republic of Korea Ministry of Environment - role in enforcing Paris Agreement, China and South Korean Air Pollution, Political implications of air pollution in South Korea, ROK trade surplus correlation with increased air pollution, Katowice Climate Change Package

iafor
The International Academic Forum
www.iafor.org

Introduction

In 2018, 17,000 people died in South Korea because of air pollution, according to the "State of Global Air 2019" report published by the Health Effects Institute (Nam, 2019).

Air pollution is identified as the cause of one third of deaths from stroke, lung cancer, and heart disease (World Health Organization, 2019). In 2017, South Korea was designated as one of the most polluted countries in the world, with estimated costs to the country of $9 billion annually. According to the website AirView, three of the most polluted cities in the world are in South Korea, including the capital Seoul (Harris and Buseong, 2017).

The fundamental cause of health problems in both humans and animals attributed to air pollution is from particulate matter suspended in the air smaller than 10 micrometers, or PM10. These microscopic substances pose great risks because it's possible for the particulates sized PM10 and smaller to infiltrate into the bloodstream or to the lungs, penetrating deep into the respiratory and circulatory systems. This may cause damage to the lungs, heart, and brain (WHO, 2019).

Particulate matter represents a harsher threat when children and asthmatics are impacted. After studying the hospitalization and health records of children, medical experts identified detrimental health effects from the air pollution measured in South Korea's population centers and concluded it's a problem that must be addressed with more care and attention. (Lee, Kim, Song, Hong, Cho, et al, 2002)

Air Pollution in South Korea

According to published environmental research, South Korea ranks amongst the most polluted countries in the world. In 2018, Norwegian researchers found Seoul to have the worst carbon footprint out of 13,000 world cities, with inhabitants producing 276.1 metric tons of carbon dioxide a year (Babe, 2018). Noelle Selin, Associate Professor of Engineering Systems and Atmospheric Chemistry at the Massachusetts Institute of Technology states that a carbon footprint is the "amount of carbon dioxide (CO2) emissions associated with all the activities of a person or other entity (e.g., building, corporation, country, etc.)." (Selin, 2010)

Poor air quality is a major topic of concern for the Republic of Korea's population - in a 2017 national survey, South Koreans identified fine dust and air pollution as their No.1 stressor in life. (Guardian newspaper, 2018). In fact, Koreans are more worried about getting sick from pollution than they are about nuclear weapons proliferation in North Korea. (Guardian newspaper, 2018). The media reported that in 2016, Korea had 243 days with moderate air quality, 76 days with bad air quality, and only 45 days with good air quality. (Haas, 2018). This leads many average Koreans to wear air masks when outside.

Long-term impact on health

There are unknowns about the future effects air pollution has on long-term health but evidence does suggest that there is a direct connection between air pollution with

higher rates of cancer, stroke, heart disease, and respiratory diseases (Nunez, 2019). Currently the most widely-reported example of the long-term effects that harmful particulates have on humans long-term is the poor state of health from the responders who attempted to rescue victims and retrieve remains at the World Trade Center catastrophe in 2001-2002 - policemen, firemen, rescue paramedics and the drivers of busses and trucks- are still developing cancer 18 years later. (Herbst, 2019).

Some 40,000 of these workers have developed health conditions, including 10,000 responders and volunteers diagnosed with various cancers associated with exposure to the toxins, according to Dr. Michael Crane, medical director of the World Trade Center Health Program at the Icahn School of Medicine at Mount Sinai in Manhattan. (Herbst, 2019). Nearly 18 years after the Sept. 11, 2001, terrorist attacks, more than 2,000 people have died of an illness related to the attacks. (Goldberg and Tracy, 2018).

That figure was provided to the Seattle Times last year by The 9/11 Victims Compensation Fund and World Trade Center Health Program. Officials at each organization told the Seattle news outlet there are no records the number of people who died from 9/11-related illness, but said, at the time, the number was likely close to 2,100. (Goldberg and Tracy, 2018)

It is expected that by the 20th anniversary of 9/11, more people will have died from 9/11-related illnesses than the 2,700 who died at the Twin Towers that day. (Goldberg and Tracy, 2018)

Effects of Air Pollution on Children and Animals

The air quality conditions at the World Trade Center for the days, weeks and months after 9/11/01 were not normal but the high rate of illness, cancer and premature death proves that particulate matter is very dangerous. Studies have been conducted examining the health threats of air pollution to children. A published report found that 543,000 children younger than the age of five die annually from respiratory disease caused by air pollution (World Health Organization, 2019). Research concluded that maternal exposure to air pollution during pregnancy is related to adverse birth outcomes such as early fetal loss, preterm delivery, lower birth weight, and more (Schwartz, 2004). Thus, air pollution is a health threat to society as a whole rather than a single age group. The negative health effects of air pollution are seen not only in humans, but also in animals. In fact, animals are more vulnerable to this issue than humans (Pal, M., Yirgalem, M., Anberber, M., Giro, B., Dasguta, R. 2015). Because animals are not as well equipped to protect themselves from air pollution as humans are, they are naturally much more vulnerable to this presence of particulate matter (Pal, M., Yirgalem, M., Anberber, M., Giro, B., Dasguta, R. 2015). The harmful gases inhaled with contaminated air are believed to affect animals in the same manner as humans, leading to organ damage in the long run (Pal, M., Yirgalem, M., Anberber, M., Giro, B., Dasguta, R. 2015). This is a problem that affects farm animals and pets alike, causing disease such as acute bronchiolitis, emphysema, and heart failure (Pal, M., Yirgalem, M., Anberber, M., Giro, B., Dasguta, R. 2015).

Regulations

In 2015, the government of South Korea (ROK) signed the Paris Agreement, joining most of the world's nations. The aim of the Paris Agreement is to reduce greenhouse gas emissions by 37% below Business As Usual (BAU) emissions by 2030. Because compliance with the Paris Agreement would ensure that roughly a million lives be saved annually by 2050 purely as a result of reductions in air pollution, it has revealed itself to be one of the most critical aspects of South Korean regulation concerning air pollution (World Health Organization, How Air, 2019).

South Korea did not get off to a good start after signing the Paris Agreement – in the very next year, 2016, the non-governmental agency Climate Tracker found that the ROK increased emissions per capita and labeled the country's efforts as "inadequate" (Mattheson, 2016). Figure below shows the grey circles are the 2020 targets, with actual emissions much higher than the progress goal designated by the Paris Agreement.

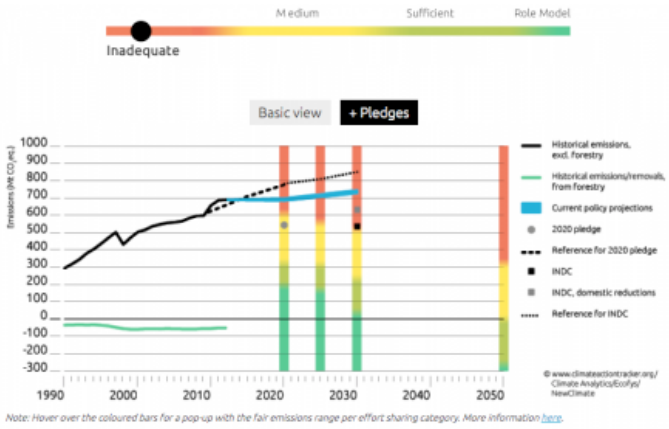

Figure 1. South Korea increased emissions in 2016 after signing the Paris Agreement (Mattheson, 2016)

The RoK's Ministry of Environment oversees South Korea's regulations concerning pollution monitoring and prevention, working with the National Legislature to enact policies that are designed to protect the environment. However, the Ministry will have a practical challenge hitting the quantitative targets of the Paris Agreement for the following profound reason: South Korea generates approximately 52% of its air pollution domestically, with the other half drifting over from the second largest economy in the world - The People's Republic of China - from the West across the China Sea and from its neighbor on the Korean peninsula the Democratic People's Republic of Korea, most often referred to as North Korea. (Da-sol, 2017)

According to the landmark atmospheric tests of air quality using measuring equipment provided by NASA, domestic air pollution in the RoK originates from industry, power generation, buildings and transportation vehicles. (Hu, 2017) The single largest contributor to air pollution is coal-fired power plants. South Korea is home to 54 coal-fired power plants, which account for 30 percent of the country's power generation (Chung, 2019)).

One of the coal-fired power plants in South Chungcheong Province is a major source of nitrogen compounds and sulfur dioxide which have chain chemical reactions in the air generating more fine dust and ozone (Lee, S. 2017). However, the role that these power plants play in polluting the nation cannot be denied (Lee, S. 2017). Thus, in July 2016, South Korea's Trade Minister announced that the country would target the closure of 10 coal-fired plants by 2025, while also replacing turbines at several power plants in order to increase efficiency and reduce emissions (Lee, S.2017). The government also stated that existing coal-fired power plants will be more tightly regulated through tougher emissions standards (Lee, K. 2017)).

The success of these regulations remain unclear as of the writing of this report. In all, the South Korean government can be said to take a moderately active role in placing regulations to reduce air pollution. However, based on the research we conducted for this paper, we do not believe that the implemented regulations are drastic enough to create significant changes in the number of days of poor atmospheric air quality.

To adhere to the standards presented by this agreement, the South Korean government has made a variety of attempts, including installment of bike-sharing stations, enactment of fines on specific diesel-fueled vehicles and the discontinuation of government parking lots (Babe, 2018).

However, many of these measures have had little success. In 2019, seven major cities in South Korea suffered record high concentrations of harmful PM 2.5 particles, leading to popular backlash over current regulation (McCurry, 2019). Following this crisis, the national assembly passed a series of bills in March to provide authorities access to emergency funds for measures to mitigate these high concentrations, such as the installation of air purifiers in classrooms (McCurry, 2019). It is unclear how effective this new regulation will turn out to be.

China

China is commonly identified as the greatest cause of Korea's air pollution, but as the NASA study concluded, less than half of Korea's poor air quality can be attributed to China. The study determined that approximately 48% of pollution originated outside of the country, from the following regions - 22% from China's Shandong Province, 9% from North Korea, 7% from Beijing, 5% from Shanghai, and a combined 5% for the three regions of China's Liaoning Province, Japan and the West Sea. (Sa-sol, 2017)

Academic experts also believe that the public blames China unfairly. The government is sitting idly by while passing the buck to China," said Kim Shin-do, a professor of environmental engineering at the University of Seoul. (Harris and Beseoung, 2017). Professor Kim's assessment of China's share of the pollution blame is 20%. (Harris and Beseoung, 2017).

The results are expected to silence those who blamed China the most for Korea's bad air quality. Some people even filed a compensation suit against the Chinese government earlier this year (Kim S., 2019). South Korea must acknowledge its own prominence in the harsh air pollution of South Korea rather than assigning blame solely to its neighbors (Hu, 2017). A 2018 study by the Ministry of Environment

found 97 per cent of Korean adults felt physical or psychological pain due to dust. Sixty per cent thought the problem was “serious” while another 30 per cent thought it was “extremely serious” (Lee, D. 2019). The National Assembly took action in February and March of 2019, passing several bills that paved the way for a 3 trillion won (US$2.65 billion) emergency fund to tackle the problem and designated fine dust as a social disaster. A second law, the Special Act on the Reduction and Management of Fine Dust, granted the government the ability to limit the use of vehicles, coal-fired power stations and building sites (Lee, D. 2019).

From the research we conducted we could not find evidence that there is a substantive plan for using alternative fuels for buses, trams and trucks in South Korea in the near future, such as biofuel or liquefied natural gas.

As in many democratic countries with multiple political parties, when a national crisis occurs, the issue becomes politicized. South Korean President Moon Jae-in (Democratic Party) proposed a joint project with China to use artificial rain to clean the air in his country, but the Chinese Foreign Ministry Mr. Lu responded "I wonder if the South Korean side has any basis that its smog is from China," noting that fine dust readings have been higher in Seoul than in Beijing recently. "All countries realize that the cause is very complicated" (Telegraph Staff, 2019).

Na Kyung-won, the floor leader of the conservative Liberty Korea Party, called for Mr. Moon to designate the current levels of air pollution a national disaster. For President Moon, the dirty air appears to be eroding his approval rating, which dropped to 44% in March, 2019 from a peak of 81% in June 2017, according to data from Gallup Korea (Lee, D. 2019).

Is Coal to blame for the fine dust particles?

The 52% of air pollution generated domestically was created by the coal-fueled power industry, diesel cars/buses, heating homes, apartments and office buildings and diversified industrial manufacturing. According to the comprehensive report measuring CO2 emissions for all world countries, South Korea is ranked 9th amongst all nations in Fossil CO2 emissions. The top 10 nations on the list contributed 67% of the planet’s CO2 gases (Muntean, et al 2018).

As noted above, South Korea is the 9th largest producer of CO2 but there are many countries in the world in addition to South Korea - especially in Europe - that have smog and pollution because coal is the primary source of power generation plants and a significant percentage of workers rely on coal production and/or economically rely on its supply chain.

This is the reason why the location of the last meeting of the UN Climate talks was significant - Katowice, Poland, which is in the heart of the Silesia Coal region. There is significant tension between the advocates of preventing further climate change and those that want to protect the jobs that coal creates - and also the wealth that a country like South Korea generates from its economic engine. The end result of the December 2018 negotiations in Poland was a document that became known as the Paris Rulebook (Evans and Timberley, 2018).

What's in the Paris Rulebook?

Nearly 200 countries signed the Declaration at the end of the Katowice conference pledging to follow a 156-page rulebook for implementing the landmark Paris Agreement on climate change. (Cuddy, 2018) The landmark Paris Agreement 2015 deal aims to limit global temperature rises to "well below" two degrees Celsius - the temperature target goal at Katowice in 2018 was 1.5 degrees. (Cuddy, 2018) The UN says the new Rulebook guidelines "promote trust among nations that all countries are playing their part in addressing the challenge of climate change" (Cuddy, 2018). A consensus was finally reached when ministers managed to break a deadlock between Brazil and other countries over the accounting rules for the monitoring of carbon credits, deferring much of the discussion to next year (Cuddy, 2018). (A discussion of carbon credits follows in the next section).

Specifically:
The 256-page common rulebook, known as the Katowice Climate Change Package, is split into thematic sections. It details how countries should monitor and report their greenhouse gas emissions and the efforts they're taking to reduce them, and how they will update their emissions plans (Cuddy, 2018). Poor countries also secured assurances on getting financial support to help them cut emissions adapt to changes and pay for damages (Cuddy, 2018).

Guidelines in the package also explain how to conduct the "Global Stocktake" of the effectiveness of climate action in 2023 (Cuddy, 2018). The process for establishing new targets on finance from 2025 onwards to support developing countries (Cuddy, 2018).

Korea's Success as a Net Exporter of Goods leads to increased Wealth

After the Cold War period ended, South Korea initiated a government-backed export policy which led to great success. Since 2008, Korea has only had two quarters with a trade deficit. The trade surplus hit a high of $12BN in 2016 (Trading Economics Reference site, 2019).

The trade surplus has declined since then, but over the last 10 years, one metric of wealth, GDP per Capita has risen sharply. In 2009, GDP per Capita was $20,843 - in 2018, it was $31,335, an increase of 50% (Trading Economics Reference site, 2019). Koreans now are ranked 28th in the world as measured by GDP per Capita wealth (Trading Economics Reference site, 2019). The data proves that Koreans export success increased the economic well-being of the average citizen, who has more money to pay for heating apartments and to travel by bus and car. Rising wealth per person leads to the ability to pay for the natural resources that create carbon dioxide - this is the core problem that conflicts with achieving the Paris Agreement targets.

Car Sales in South Korea, 2008-2018

In 2008, Koreans bought 1.2 million cars and light trucks (Dement, 2019). Sales rose steadily and hit a peak of 1.8 million in 2015(Dement, 2019). In the last three years, sales have fallen by less than 1%, with 1.78 million cars and light trucks sold in 2018(Dement, 2019). This means that it's reasonable to conclude that the pollution

generated from private motor vehicles should not be increasing in the very near future. (Dement, 2019)

Year	Units Sold in South Korea
2018	1.784.614
2017	1.761.404
2016	1.795.215
2015	1.800.984
2014	1.629.763
2013	1.511.931
2012	1.516.300
2011	1.553.062
2010	1.541.433
2009	1.439.546
2008	1.200.283

Data from (Dement 2019)

What about the innovation of trading carbon credits?

Several emissions-trading schemes (ETSs) have been established to reduce CO2 emissions, such as the EU ETS, California-Quebec ETS, and New Zealand ETS, among others (Choi and Qi, 2019). The ETS provides a way to reduce pollutant emissions using market measures, which is more scientific and effective than compulsory administrative measures (Choi and Qi, 2019). The main compliance tools under the carbon ETS involve directly decreasing CO2 emissions and purchasing emission allowances, and thus, power plants must be well-versed in these two measures' costs and benefits (Choi and Qi, 2019).

Korea's coal-fueled power plants have the potential to play a key role in reducing carbon emissions, as they account for 43% of the nation's electricity generation and approximately 25% of its total carbon emissions (Choi and Qi, 2019). The energy and electricity-generation sectors collectively account for 43.6% of the ETS market's total quota, and thus, the Korean ETS' effectiveness should be based on that of the coal-fueled power industry (Choi and Qi, 2019).

Korea is the 11th largest economy world-wide and consumed approximately 2.2% of the world's total primary energy in 2017, making it the eighth-largest global energy consumer. Moreover, Korea accounted for 2.3% of global coal consumption in 2017, or sixth worldwide (Choi and Qi, 2019). To shoulder more of its various responsibilities—from curtailing global carbon emissions to relieving burdens on the domestic environment—the Korean government established its "low carbon-green growth" national carbon-reduction policy in 2009, then passed a law mandating decreased national CO2 emissions by 37% below business as usual (BAU) levels by 2030 (Choi and Qi, 2019).

Proposed Ideas that can make a substantive change in air pollution

The Korean government should strengthen its regulations to more effectively implement a green economy. Policymakers could impose a carbon tax; substantially

decrease the carbon emissions-free quota; and provide more incentives, especially to the energy-intensive, resource-saving coal-fueled power plants. The common “man in the street” in Seoul wants to hold China responsible, as scientists have attributed roughly 50% of harmful particulate matter pollution drifting over from multiple regions of China. However, it will not be easy to craft a mutually agreeable solution with the Communist power.
(Choi and Chao, 2019)

Conclusion

This paper highlighted a conundrum that the citizens of South Korea face. The success of the government-backed economic programs which emphasized investments in manufacturing export goods was successful in creating a positive balance of trade, which accrued to the average worker as measured by significant increases in the per capita GDP. Companies that are selling goods at a profit want to produce more – this led to an increase in industry-related air pollution. Workers with higher wages can afford to keep the heat on in their residences – this led to an increase in CO2 emissions. And a stronger economy means more cars and trucks on the road, which also leads to an increase in air pollution.

In 2019, only four years after the signing of the Paris Agreement, South Korea experienced a “national emergency” because of persistent air pollution, according to the President. The National Legislature took action in the Spring, but it’s too early to judge the policy implementation effective. It is hard for observer who have studied the issue of South Korea to be optimistic at this time that the country can reduce it’s CO2 emissions 37% in 11 years.

References

Babe, A. (2018). High Flying Ideas? Betting on Technology, the South Korean Capital Deploys Drones to Fight Smog. *US News and World Reports,* Retrieved from https://www.usnews.com/news/world/a rticles/2018-08-08/seoul-turns-to-technology-to-battle-air-pollution

Choi, Y. and Qi, C., (2019) Is South Korea's Emission Trading Scheme Effective? An Analysis Based on the Marginal Abatement Cost of Coal-Fueled Power Plants, *Journal of Inha University*, Incheon, Korea

Chung, J. 2019, June 18 South Korea fires up on renewables, to close more coal plants, *Reuters*, retrieved at https://www.reuters.com/article/us-southkorea-energy-renewable-analysis/south-korea-fires-up-on-renewables-to-close-more-coal-plants-idUSKCN1TJ0JK

Cuddy, A. (2019) What is the COP24 climate change rulebook and why do we need it? Euronews answers, *EuroNews,* retrieved from https://www.euronews.com/2018/12/16/what-is-the-climate-change-rulebook-adopted-at-cop24-and-why-do-we-need-it-euronews-answer

Da-sol, K. (2017, July 19), Half of fine dust from Korean sources: study, *The Korea Herald*, retrieved from http://www.koreaherald.com/view.php?ud=20170719000994

Demant, Bart, CarSalesBase.com Blog, 2019, retrieved at http://carsalesbase.com/totalmarket-sales-country/south-korea-car-sales-data/

Evans, S and Timberley, J (2018, December 18), COP24: Key outcomes agreed at the UN climate talks in Katowice, Carbon Brief, retrieved at https://www.carbonbrief.org/cop24-key outcomes-agreed-at-the-un-climate-talks-in-katowice

Ferreira, J. (2019) South Korea Balance of Trade, *Trading Economics*, Retrieved at https://tradingeconomics.com/south-korea/balance-of-trade

Goldberg, N. and Tracy, T (2018, September 10) So many deaths from 9/11-related illnesses, victims' fund may run out of money, originally published in The Daily News (New York), retrieved on https://www.seattletimes.com/nation-world/so-many-deaths-from-9-11-related-illnesses-victims-fund-may-run-out-of-money/

Haas, B. (2018, May 15) South Koreans more worried about air pollution than Kim's nukes, *The Guardian*, retrieved at https://www.theguardian.com/world/2018/may/16/south-koreans-more-worried-about-air-pollution-than-kims-nukes

Harris, B. and Buseong, K. (2017, March 29) South Korea joins ranks of world's most Polluted countries, *Financial Times*, retrieved from https://www.ft.com/content/b49a9878-141b11e7-80f4-13e067d5072c

Herbst, D. (2019) 'We Are Seeing People Dropping Like Flies': Meet the 9/11 First

Responders Now Fighting for Their Own Lives, People.com, retrieved at https://people.com/politics/911-responder-deaths-fight-congress-victims-compensation-fund/

Hu, Elise, (2017) Armed With NASA Data, South Korea Confronts Its Choking Smog*, National Public Radio,* retrieved at https://www.npr.org/sections/parallels/2017/10/10/552264719/armed-with-nasa-data-south-korea-confronts-its-choking-smog

KIM JAEWON, (2019, April 2) 'Killer dust' pollutes South Korea's relations with China, *Nikkei Asian Review, retrieved at* https://asia.nikkei.com/Spotlight/Asia Insight/Killer-dust-pollutes-South-Korea-s-relations-with-China

Kim, S., 2017, July 19) 52% of fine dust generated in Korea, *Korea Times*, retrieved at http://koreatimes.co.kr/www/common/printpreviews.asp?categoryCode=371&newsIdx=233295

Lee, David (2019, March 15), China is to blame for South Korea's air pollution. Really?, *South China Morning Post,* retrieved from https://www.scmp.com/week-asia/healthenvironment/article/3001741/china-blame-south-koreas-air-pollution-really

Lee, J.T., Kim, H., Song, H., Hong, Y.C., Cho, Y.S., Shin, S.Y., Kim, Y.S. (2002). Air Pollution and Asthma Among Children in Seoul, Korea. *Epidemiology*, 13(4), 481 484. Retrieved from https://journals.lww.com/epidem/Fulltext/2002/07000/Air_Pollution_and_Asthma_Among_Children_in_Seoul,18.aspx

Mattheson, South Korea leads list of 2016 climate villains*, Climate Home News*, retrieved From https://www.climatechangenews.com/2016/11/04/south_korea_climate_villains/

McCurry, J. (2019, March 13) 'Social disaster': South Korea brings in emergency laws to tackle dust pollution, *The Guardian,* retrieved at https://www.theguardian.com/environment/2019/mar/13/social-disaster-south-korea-brings-in-emergency-laws-to-tackle-dust-pollution

MUNTEAN M., GUIZZARDI D., SCHAAF E., CRIPPA M, Fossil CO2 emissions of all world countries - 2018 Report, *EU Fossil Hub*, retrieved at https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-researchreports/fossil-co2-emissions-all-world-countries-2018-report

Nam, S. (2019,4,4. Air pollution causes 17,000 deaths in S. Korea in 2017: Study. Yonhap News Agency, Retrieved from https://en.yna.co.kr/view/AEN20190404010800315

Nunez, C. (2019) Air pollution, explained, *National Geographic*, retrieved at https://www.nationalgeographic.com/environment/global-warming/pollution/

Pal, M., Yirgalem, M., Anberber, M., Giro, B., Dasguta, R. (2015) Impact of Environmental Pollution on Animal Health, Journal of Natural History, Vol. 11, No 1, retrieved at https://www.researchgate.net/publication/327871070_Impact_of_environmental_pollution_on_animal_health

Schwartz, Joel, 2004, Air Pollution and Children's Health, *American Association of Pediatrics*, 2004, retrieved at https://pediatrics.aappublic, ations.org/content/113/Supplement_3/1037.short

Selin, N. (2010, May 25). *Carbon Footprint.* Retrieved from https://www.britannica.com/science/carbon-footprint

Telegraph Staff, 2019, South Korea proposes artificial rain project to combat Seoul air pollution, retrieved at https://www.telegraph.co.uk/news/2019/03/06/south-korea-proposes-artificial-rain-project-combat-seoul-air/

Contact email: dougkleinteacher@gmail.com

The International Academic Forum (IAFOR)
Sakae 1-16-26-201
Naka Ward, Nagoya, Aichi
Japan 460-0008
ww.iafor.org