

Such a fascinating subject! How did you decide to choose this topic? (Please add anecdotal material that may come to mind. Did you play with insects as a little girl? Have you ever been bitten by an insect, or stung by one? Did such an event make you mad? Have you ever considered any insects as friends?)

I have my mother to thank for my views on insects. As an artist, she used to be an entomological illustrator for University of Connecticut and the Natural History Museum in London and was even the founder of a “Bug Lovers Club” when she was young. Hearing her involvement and compassion towards insects made me less skittish about them from an early age. We were a household that tried to catch and release bugs rather than kill them.

Growing up, I spent many summers collecting fireflies and caterpillars in jars to watch them. However, I never considered myself much of an insect enthusiast. Sure, I’ve been stung by yellow jackets and fire ants and have been creeped out by cockroaches who have crawled on me. Yet, these events have not made me resent insects at all. Bugs exist in this world, just like humans do, and I believe we are even more to blame for invading their space rather than them invading ours.

My first real exposure to insects as a commodity was during my first trip to China in 2009 on a study abroad when I was a marketing undergraduate student at the University of West Georgia. I went to a food market (“Snack Street”) in Beijing full of silkworms, crickets, scorpions, and many other bugs on bamboo skewers sold as novelty street food. My tour guide informed us that these were mostly offered as a tourist gimmick and not typically consumed by locals.

Upon graduating college, I decided to try a vegan diet. I became wildly curious and experimental in the kitchen, trying new diets and recipes regularly. Since I love to eat, I grew increasingly interested in how to cook, prepare, and grow my own food.

Five years later, I went backpacking around Asia and was informed that I may come across fried crickets in Thailand. Unfortunately, I only came across them once in Bangkok. Despite being curious to try them, I passed, thinking I would have another opportunity but never did. I then spent several weeks volunteering on an aquaponics farm south of Shanghai and became fascinated with alternative agriculture. The amount of land and resources required in traditional farming could be replaced through more sustainable methods such as aquaponics, urban farming, and insect cultivation. Not only did I have interest in food production on a personal level, but the implications of these techniques on a large scale could also help alleviate malnutrition, starvation, and poverty globally. I wondered why these methods weren’t the norm and kept that question in the back of my mind.

Another five years went by and my obsession with food persevered. Feeling stuck career-wise led me to pursue a PhD in international business, guided by my background in marketing and wanderlust. The increase in global consumption, with the help of online shopping and increasing disposal incomes, has also increased the amount of global waste. My interests in food, waste, and insects has shaped the context for my research interests of sustainability in international business, and I feel extremely fortunate to have support from my department and professors at Georgia State University.

Please describe the extent of your research.

Plastic waste is getting a lot of press lately, as it should; it is an extremely important and devastating problem. However, many people don’t realize the gravity and magnitude of food waste’s impact on our climate challenge. We assume that since organic matter (like food, paper, and manure) is naturally biodegradable, it’s not harmful to the environment. But food and organic waste release methane, which is over 30-84 times more dangerous than carbon dioxide^{1,2}.

Globally, food and organic waste comprise the largest category of municipal solid waste at 63%, compared to plastic at 12%³. In the United States, food and organic waste make up approximately 60% of MSW, compared to plastic at 13%⁴. Therefore, it bears repeating that food and organic waste make up the single largest category of municipal solid waste in the world. So, if we remain complacent with this statistic, food and organic waste will remain an unassuming yet massive detriment to this planet.

The business of insects can be broadly organized into three main industries: food for human consumption, feed for animals, and waste management. I have interest in all three, as well as others. However, my attention shifted towards waste management due to its reduced stigma when sharing my interests with western audiences.

Ultimately, to me, it makes so much sense to focus on collecting insects rather than killing them (i.e. using insecticides, pesticides). Insects are an abundant resource, as is waste. Therefore, why not capitalize on these resources in as many ways as possible?

The ultimate business / marketing challenge is to take something that has little or no value and sell it for a profit. Markets in other cultures and countries often value products and services differently. For example, America produces a lot of chicken but does not value certain parts of the chicken, like chicken feet. In contrast, China greatly values chicken feet and will buy them at a higher price than the American market, which results in international trade. I believe that other seemingly-worthless resources, like food waste and insects, can be marketed in a way that not only shifts their value but also shifts the processes and business models surrounding them to be more sustainably-oriented.

Identifying and utilizing markets in other countries provides tremendous economic and international business opportunities. We think of maximizing efficiencies and minimizing inefficiencies when we think of optimal business models. However, many byproducts and externalities are dismissed as sunk costs and costs of doing business rather than reevaluating them for optimization or profit opportunities.

One of my broad research objectives is to identify contexts in which businesses behave counter to their theoretical expectations, particularly in the circumstances of waste. I'm most curious about how business costs (waste, externalities) can turn into business profits. For example, can intentional design around externalities provide lucrative business opportunities in both domestic and international markets?

Circular economy focuses on this philosophy for conscious manufacturing, but my research focuses more specifically on the disposal component within this system. I think it's great if we can redesign straws so that they don't litter our oceans and kill turtles. But what about all the straws that already exist in the world that aren't decomposing? To me, the issue of existing waste is an equally critical problem to the issue of reinventing products to be more sustainable from the start.

How much of a waste management crisis is there? In the U.S.? In China? In South Korea? Elsewhere in the world?

Part of the problem with food waste is terminology. Food can be wasted throughout different stages of its life cycle: production, processing, distribution, retail, and consumption. In developing countries, food is wasted most in the production stage due to inadequate transportation and storage, which is considered food loss. In developed countries, food is wasted most in the consumption stage when people buy excess food and it goes bad before it is consumed or is simply thrown away (like in restaurants), which is considered food waste. Additionally, food waste also comprises inedible components, like shells, bones, peels, rinds, etc. Therefore, the various types of food that are lost and wasted are difficult to measure and compare, especially since standards and evaluations vary across and between countries.

Another major problem with food waste is the availability and consistency of measurements and data. Some sources indicate that the U.S. wastes the most food of any country in the world; responsible for over 90 billion kg of food waste, or 278 kg per person per year⁵. However, the same source the following year indicates that the U.S. wastes only 95 kg per person per year⁶.

Despite having much higher populations, India and China produce 68 and 62 billion kg of food waste, respectively, or 51 and 44 kg per person per year⁵. Another notable country for food waste is Indonesia, which produces between 79-82 billion kg of food waste, or 300-315 kg per person, per year⁵.

In contrast, while United Arab Emirates only produces 1-8 billion kg of food waste per year, if we look at food waste per capita, UAE produces between 196-986 kg of food waste per person per year, higher than any other country regardless of population size.

Globally, one-third of all food produced for human consumption is lost or wasted annually⁷. Every year, approximately 1.3 billion *tons* of food is wasted while 821 million people around the world are undernourished^{8,9}.

This severe imbalance in food distribution costs the United States \$218 billion USD¹⁰ and the world \$940 billion USD annually⁸. The concern over food waste is neither unique nor novel; however, this universal and urgent issue has not received the attention it critically deserves, particularly in business literature and research.

Additionally, policies surrounding the food waste crisis often target prevention and reduction strategies but overlook the equally important issue of disposal. Even with prevention and reduction, waste disposal continues to be a reality that all businesses, firms, and consumers face, and therefore requires active and intentional strategies and policies surrounding waste disposal activities.

What are the most interesting solutions from your perspective?

The Smithsonian estimates that at any given time, around 10 quintillion (10,000,000,000,000,000,000) insects are alive on this planet¹¹. That's approximately 200 million insects for every human. Of these, over 2,000 species are edible¹². Between pollination, soil aeration, scavenging, and population control, insects play an essential role to much of life's existence on this planet. It's easy to default to disgust and fear when it comes to bugs due to specific bad experiences with a small portion of these creatures, but the reality is that those harmful to humans comprise an extremely small fraction of the entirety of the myriad of species of insects.

Therefore, education is key! The more we know about something, the less we fear and the more open to it we become. Here are some examples of how we as individuals can help create a smaller food waste footprint:

Reduction: Only grow and purchase what we need

Prevention: Smarter storage, innovative products like Apeel¹³

Protein alternatives (for humans, pets, and livestock): Crickets (powder), mealworms, silkworm pupae, grasshoppers, locusts, bamboo worms, termites, ants, etc.

Disposal: Composting with black soldier fly larvae (BSFL) and worms, wax worm and mealworm enzyme replication to break down Styrofoam and other plastics

BSFL work well with vermicomposting (worms) to break down organic waste very rapidly! It's pretty easy to set up and maintain, making it a fun, educational, and effective solution for household food waste. A friend of mine actually discovered BSFL accidentally when vermicomposting for pet waste. She (and her entire family) struggled to produce enough waste for the complementary waste-fighting duo of worms and flies!

If there is no support for innovative ways of dealing with waste what will be the consequences? Can you give specific examples of how bad things could get?

It's no secret that the earth continues to rise in temperature. The escalation of dangerous greenhouse gases contributes substantially to the heating of this planet. The one we hear about most is carbon dioxide. While the amount of carbon dioxide makes up the overwhelming majority of greenhouse gas emissions, the potency of methane far surpasses carbon dioxide when it comes to trapping heat^{1,2}. Methane is emitted from energy and industry facilities, but the main source of methane comes from livestock and organic matter, such as food and manure waste.

The United Nations predicts a world population of 8.5 billion by 2030 competing for basic resources like water, land, and food. Traditional agricultural practices are not sustainable to maintain this population. Alternatives methods, like urban agriculture, aquaponics, and insect rearing are not only exciting but they are necessary.

The beef industry is considered to have the largest carbon footprint¹⁴, mainly due to it being responsible for an enormous amount of methane emissions. Therefore, optimizing agriculture has the potential to alleviate many sustainability development goals (SDGs), such as climate action, food scarcity, poverty, overall health, water and land quality, and clean energy.

That's what's so exciting about the business opportunities of bugs. The sheer variety of industries in which they can shift systems and operations have overlapping and lasting potentials. The planet's temperature is going to rise no matter what. But what we can try to do is reduce the amount that it rises.

Are you aware of the huge dumps in Brazil and have you heard of the art work of Vik Muniz who has extracted art from those dumps?

I had heard a bit about the dumps in Brazil, but I was not aware of the artwork. I've seen "trash art" in other places, and while this is a great way to reuse waste, it still begs the question of what will ultimately happen to it? If we reuse plastic over and over again, that's great, but we must have a solution for disposing of every material. Reincorporation back into the supply chain supports circular economies, but an embarrassing amount of municipal solid waste continues to be diverted to landfills that continue to leech toxic materials back into the earth.

In what ways do you think human behaviors can be changed?

Research on consumer behavior, particularly around sustainability, is encouraging¹⁵⁻¹⁷. Aschemann-Witzel et al. identifies segments of consumers based on their behaviors related to food waste to suggest specific policies for each segment¹⁸. San Francisco along with many cities in South Korea and China have experienced tremendous shifts in consumer behaviors based on mandating food waste disposal activities such as composting and Pay-As-You-Throw (PAYT) programs. These programs not only help consumers and cities become more sustainable and environmentally-responsible, but they actually stimulate the economy by literally turning previously-worthless trash into profitable treasure.

Additionally, the European Commission (2003) concludes that communities that implement Pay-As-You-Throw programs do not experience large increases in illegal dumping, likely due to the relatively low costs and the existence of infrastructure that supports this scheme^{19,20}.

What are the main impediments to changing current human practices?

Humans as a species have grown accustomed to following the path of least resistance. We live in an age of instant gratification stimulated by short-term motivations. We've also reached a point where the topic of climate change dominates our media and conversations.

Unfortunately, awareness and knowledge are not enough to change practices and behaviors. The gravity of the crisis we face is overwhelming, which can paralyze action because we don't even know where to start. Without the combined cooperation of policies from government, operational changes from firms, and household shifts from individuals, we cannot realistically expect to improve our current state. I believe it's going to take a collaborative effort from everyone to make a difference. From a marketing standpoint, making these changes attractive is fundamental. From a humanity standpoint, even if the changes are unattractive, they are simply no longer optional.

In the past, people invested in products that lasted because we valued quality over quantity. As convenience became more valuable to us as a society, we prioritized countless disposable products over a finite number of eco-friendly ones. These days, the urgency and magnitude of climate change is shifting our mentality back to products that are made to last and manufactured from materials that are sustainable.

Ultimately, I believe our own values and mentality towards the planet are the main impediments to changing current human practices. We have the technology, materials, and creativity to solve these problems. What we struggle with is long-term thinking, responsible attitudes, and compassionate behaviors.

How do you explain the absence of concern by some companies (Chick-Fil-A and plastic straws, contact lens manufacturers)?

I think it's easy to point to firms and say that they have no concern for the environment, because it's human nature to look for someone to blame for injustices in the world. However, the ultimate goal of firms is to sell products and services at a profit. If consumers demand convenient, disposable, individually-packaged products, firms respond to that demand. The challenge is to shift the priorities of both consumers and firms to consider environmental and waste consequences when making purchase and product development decisions. Rather than trying to pinpoint whether the chicken or the egg should make the first move towards sustainable decisions, they simply both should. Changes need to come from consumers and firms alike, and ultimately need the support of government to implement these changes.

Plastic straws have gotten a lot of press, and if that's what it takes to get some people concerned about the environment, then that's a win. But how easily we get riled up over straws yet dismiss all the plastic bags we use at grocery stores or the packaging materials from our Amazon purchases. That disconnection between one issue and the other is the greatest concern of all. We need to recognize that if we care about straws harming turtles then we should also be concerned with how other products affect the world around us. Unfortunately, this revelation is easier said than done because once we start pulling at that thread, the magnitude of our reality becomes incredibly overwhelming. The daunting task of being a responsible consumer is comparable to dieting. Even if we want to do it, it ultimately feels like too much change that takes too much time and requires too much effort to execute. This is why it's so important for us to do little, manageable things every day to work towards the common goal to ensure a better planet.

In the case of contact lens and printer cartridge manufacturers, many of them have recycling programs that encourage consumers to send back the packaging so that it can be reincorporated into the manufacturing process in support of a circular economy.

Companies that are forming these days are commonly building their business models around sustainable values. In this sense, they are born-sustainable. In contrast, existing companies that are not already

sustainably-oriented can reactively shift their practices in a sustainable direction, especially when encouraged by consumers, regulations, or both. Either way, our climate crisis, growing population, and finite resources are forcing firms to be sustainably-oriented either upon conception or through evolution.

Do you know of any companies making positive steps to reduce waste?

There are many companies doing awesome things to reduce waste!

Goodr²¹ is a company from Atlanta that utilizes mobile app technology to alleviate logistics issues to connect companies with excess food with organizations that provide food to those in need. I'm trying to connect GSU's Sustainability Initiatives with Goodr to ensure that our campus' excess food goes to people who need it.

Apeel Sciences¹³ is a company that uses plant-based material incorporated into a spray that mimics the peel of fruits and vegetables to extend the shelf life of produce in a natural, chemical-free way. Their time-lapse videos of produce with and without the coating are addictive to watch!

Loop²² is a company that I cannot wait to come to Atlanta. They work with companies that produce commonly-purchased consumer goods to provide a closed-loop packaging system that recycles containers (like the once-common glass bottles of milk) to reduce plastic and packaging waste.

Many companies are doing great things, and it's up to us to be conscious and intentional with our purchase behaviors and to whom we give our money.

Additionally, scientists have found an enzyme (found in some bacteria as well as certain insects like wax worms and mealworms) that can consume and break down plastic into its original components^{23,24}. It's a tall order, but if this enzyme can be optimized and mass-produced, then it may revolutionize our plastic problem.

Any specific concerns about the future of our oceans?

The state of our oceans is extremely disturbing given the amount of waste that is dumped into them. Particularly, the Great Pacific Garbage Patch is devastating. The amount of plastic that litters our oceans, especially on such a micro scale, is terrifying. The biggest problem is that this plastic cannot easily be filtered out. However, The Ocean Cleanup²⁵ is a non-profit organization that is spearheading the effort to remove as much as we can. They aim to reduce the 1.8 trillion tons of plastic by 50% every 5 years.

Historically, products involved far less packaging. Millennials and Gen Z-ers didn't experience the glass bottles of milk that were picked up and recycled with each week's delivery. That used to be a norm of how many things were consumed. Plastic bags for each item of produce only recently became typical because plastic bags weren't introduced to the market until the 1960s. The push for convenience inspired individually-wrapped products that resulted in enormous amounts of plastic and packaging waste.

An important distinction is that disposal is not synonymous with bad and recyclable is not synonymous with good. Bamboo utensils can be manufactured to be disposable and will decompose at a much faster rate than plastic, which is recyclable. On average, it takes an apple core 2 months to decompose, a cigarette filter 1-5 years to decompose, and a plastic bag 10-20 years to decompose. However, much of the information we receive comes with a lot of fine print that we don't even realize is there.

For example, it theoretically takes 1 million years for a glass bottle to decompose. This sounds terrible for the environment, right? However, that's because of the way it's worded. The chemical composition of glass is silica, or silicon dioxide (SiO₂), which is the major component of sand. Decomposition involves a chemical

breakdown into smaller elements. Glass is an inert material, meaning it is not chemically reactive. So, over time, glass will merely break back down into sand rather than decompose.

Similarly, plastic also does not technically decompose, but the material leftover from being broken down is just very small pieces of plastic called microplastic. Microplastics contaminate land and water sources and are consumed by species throughout the food chain. When consumed, plastic can trigger a response of satiation despite its lack of nutritional value, which eventually leads to the death of its host.

I believe that, for the most part, people don't maliciously do things that are poor for our planet, but without the proper knowledge and information, it can be very difficult to navigate the right thing to do when it comes to waste. The confusion of single-stream waste/recycling collection versus manual source separation is an ongoing challenge. Even further additions to the landscape are the false claims of biodegradable products like plastics and wipes that don't actually break down.

Can bugs be used on the islands of waste floating in the Pacific? Or how about their use on the waste clogging streams and rivers such as in Haiti?

Unfortunately, I'm not sure of how bugs can be used directly in the Great Pacific Garbage Patch. But the enzyme in wax worms and mealworms could be used on the plastic that is collected from The Ocean Cleanup²⁵.

Luckily, some exciting research has recently surfaced where ferrofluid may be used to essentially act as a magnet for plastic²⁶. This technology was originally discovered by a NASA engineer, Steve Papell, in 1963, but was developed to alter the properties of rocket fuel for space conditions for Apollo missions. Recently, an 18-year old from Ireland, Fionn Ferreira, played around with magnetite powder in vegetable oil to see if he could use this same concept to attract plastic. Through preliminary testing, he has been able to remove approximately 80% of polypropylene plastics from contaminated water samples.

Also, using nanotechnology, nano-coils can decompose microplastics into "organic intermediates [that are] environmentally benign to aquatic microorganisms" and even "serve as a carbon source for algae growth"²⁷.

So, we mustn't give up hope!

At the conference I met a professor who was much taken aback by your research. Growing up, he said he watched too many movies where bugs got out of control. "They are not the friends of human beings," he said. If uncontrolled they can create great harm and destruction? Do you have any favorite bug horror movies? Did you like Ripley Scott's Alien?

To reiterate from question 4, bugs are very permanent, present inhabitants of this planet. According to an article from the Annual Review of Entomology, "1.5 million, 5.5 million, and 7 million species of beetles, insects, and terrestrial arthropods, respectively" populate this earth²⁸. Only a very small percentage are harmful to humans.

The way I see it, humans are far more detrimental to this planet than are insects. Insects do a much better job at repairing the environment²⁹ in response to damage that we create. We spend millions of dollars every year on methods and chemicals to kill these creatures without considering that we are the ones encroaching on their territory. A recent study shows that cockroaches are becoming immune to insecticides³⁰. So, why not spend our money and energy trying to figure out how to use them instead of how to get rid of them? They are clearly here to stay. The Chinese use them for medicinal purposes³¹ and oil waste consumption³², and researchers have even found ways to use them for disaster relief and surveillance³³.

I understand this professor's anxiety. Disrupting natural ecosystems is not a topic that should be taken lightly. If species of any plant or animal are introduced to an unfamiliar geographic region, the possibility of invasion, is of great concern (like in the example of rabbits in Australia or kudzu in Atlanta). However, this fear highlights the exact opportunity for international business to focus on naturally-occurring resources and habitats instead of trying to artificially recreate them in foreign locations. Businesses for rearing and processing insects can remain local but export their goods and byproducts to other countries.

The ecological concern over insect invasion seems to be unusually asymmetrical to the ecological concern over their disappearance. We seem to have no problem disrupting ecosystems by exterminating them but fail to consider the consequences of the bigger picture of other species that rely on these creatures. Let us not forget how dependent we are on bees for pollination. Many pesticides³⁴ harm bee populations. The hyper focus on eradicating all insects without consideration for the magnitude of its effects is equally as dangerous as the magnitude of effects from the invasion of them.

In my opinion, the bigger concern here is that the rate of insects is declining, which contributes to the evidence of the pending sixth mass extinction that is imminent³⁵.

What will you be doing next? Will you be continuing this research?

Right now, I'm concentrating on my dissertation! My dissertation involves culture, sustainability, and their intersection in international business. I hope to have a long career of research ahead of me and my constant challenge is to narrow my focus since my interests are clearly vast. So, I remind myself daily that I don't need to research all of them right now and that I need to pace myself. Luckily, I spent a few years doing triathlons before starting the PhD program, so I feel like I have a leg up in understanding mental and physical endurance. Thank you so much for the opportunity for me to talk about my passions!

Phil Bolton – Publisher, *Global Atlanta*, <https://www.globalatlanta.com/author/pbolton/>
Sarah Ku – PhD candidate, *Georgia State University*, www.sarahku.com
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