Circular Economy and Sustainability
https://doi.org/10.1007/s43615-022-00155-z

OPINION PAPER

A Real-World Scenario of Citizens' Motivation and Engagement in Urban Waste Management Through a Mobile Application and Smart City Technology

Menelaos Neofotistos[1] · Nafsika Hanioti[1] · Eleni Kefalonitou[1] · Anastasia Z. Perouli[1] · Konstantinos E. Vorgias[1,2]

Received: 5 August 2021 / Accepted: 13 January 2022

Abstract
Circular bioeconomy is a key socioeconomic model for advancing the United Nations Global Sustainability Goals and promoting environmental and resource sustainability. However, circular bioeconomy concepts are unknown to most people and politicians worldwide who still have a fragmented picture of sustainability. Common perception of waste needs a cultural shift from "disposable" to commodity. This can happen with effective communication, active citizens' education, and awareness and engagement in core bioeconomy experiences and activities, like urban waste management and environmental sustainability. Citizen engagement methodologies are multiple. This paper proposes the combined use of Information and Communication Technologies (ICTs), citizens' hands-on project involvement, and a direct rewarding system. Similar European examples are displayed, while our key case study is the bitter orange waste problem in the metropolitan region of Attica in Greece, where approximately 40,000 tons of bitter oranges per year remain unmanageable and unexploited, causing serious problems. The Bitter Orange Project aims to educate citizens on bioeconomy and biomass value, hopefully changing the perception of urban waste through their rewarded engagement in fruit collection to produce high added value materials. This can be a versatile platform for urban waste management projects through citizen science regardless of the type of biomass. The project aims to engage all possible local society stakeholders to multiply awareness. The target of this paper is to highlight that environmental problems related to biomass misuse are closer than the average citizen experiences, and that active involvement of society through rewarding can help raise awareness.

Keywords Circular bioeconomy · Mobile application · Smart cities · Added value materials · Social awareness · Urban waste management

✉ Anastasia Z. Perouli
perouli.anastasia10@gmail.com

[1] CITRION SCE, 21300 Kranidi, Argos, Greece

[2] Department of Biology, Section of Biochemistry-Mol. Biology, National and Kapodistrian University of Athens, Panepistimiopolis Zografou, 15784 Athens, Greece

Published online: 25 May 2022

Why Circular Economy?

Speeding climate change consequences with heavy social impact, and studies claiming that fossil fuel will become scarce within the next 100 years [1] have led to new regulations and legal acts on behalf of the European Union (EU) and the United Nations (U.N.), to create an innovative framework and establish a roadmap to a sustainable future [2]. With the European Green Deal [3, 4] and the United Nations Global Goals [5], certain directions are given to enhance both market adaptation and social activation toward the new challenges and to compensate for inevitable inconveniences in social, economic, and political levels.

In this perspective, circular economy has become a key tool for enhancing sustainability [6]. It is an economic model that separates a product manufacturing cycle into distinct levels of production where the output of one process is considered to be the input of a next one [7]. Each level can produce a final product and/or a material (multiple outputs) that feed the input of other processes, maintaining the value and usefulness of materials that would otherwise be characterized as waste. This leads to the re-evaluation of waste as a resource to create new products, while compensating material scarcity and minimizing the usage of intermediate resources (i.e., water, energy) and environmental pollution. Circular economy–based production can use organic, non-organic, and fossil-based raw materials under a zero-waste concept [8].

Circular Bioeconomy as Part of the Global Circularity Concepts and Policies

As a part of the above rationale, biological resources have gained focus since they are by definition renewable [9]. When bio-resources, like herbal-based and animal-based raw materials, are used as inputs in manufacturing through a sustainable and ethical production model, the concept of bioeconomy is introduced [10]. The production technologies used for this purpose incorporate technological machinery, chemical and biochemical processes, and/or microorganisms as cell factories to produce intermediate and final bio-products. Incorporating the use of renewable bio-resources in the circular logic creates the concept of circular bioeconomy [11].

Circular bioeconomy consists of 3 main pillars:

i. Utilization of wastes and intermediate production process residues as a resource
ii. Utilization of biological resources or naturally derived resources only
iii. Utilization of a sustainable production process

Although other authors have given different definitions on circular bioeconomy, we tend to agree with the definition given by P. Stegmann, M. Londo, and M. Junginger [12]. In an attempt to summarize this concept, they concluded that "the Circular Bioeconomy focuses on the sustainable, resource-efficient valorization of biomass in integrated, multi-output production chains, while also making use of residues and wastes and optimizing the value of biomass overtime via cascading."

In international policy making, we can see references to circular bioeconomy in UN's Sustainability Development Goals (SDGs). The 17 Goals aim to define a clear roadmap for a sustainable future and to create a framework of criteria through which circular

bioeconomy, among other strategies, can be evaluated for their efficiency. Circular bioeconomy can positively affect most Sustainable Development Goals (SDGs) when applied under defined policies, strategies, and regulations to ensure sustainability [13, 14].

Europe responded to the UN's SDGs to align the standards to the special requirements of the European territory. This European adaptation, the European Green Deal, promotes "a new growth strategy" toward a "modern, resource-efficient and competitive economy" with minimized "net greenhouse emissions by 2050." The Green Deal's Action Plan [3] emphasizes new economic approaches such as the circular economy, bioeconomy, and circular bioeconomy. However, member states present different progress depending on whether they have adopted a national strategic approach on circular bioeconomy. Only 9 member states out of 27 have adopted a national bioeconomy strategy, plus the BIOEAST Initiative [15, 16].

The Results of the Above Policies

To achieve the goals set by the European Green Deal, the issue has been approached from a strategic planning, legislative, and economic motivation point of view [17]. European Union uses market drives and directives such as the "the polluter pays" principle and "the extended producer responsibility" to initiate change on behalf of the producers with a "bottom-up" approach [18, 19].

Even in the citizen awareness field, the market drive prevails. High emphasis is given to the "education and skills" driven bioeconomy in its EU policy debut. With the aim being a biotechnology-lead bioeconomy with efforts for fossil resources replacement, highly skilled labor force and industry were required [10]. In this regard, education becomes a key factor raising people's awareness of environmental issues and is delivered both from central EU digital portals and from local national policies and actions [14, 20]. The methodologies followed concern effective communication and education and are widely based on cultivating knowledge and skills by financing regional training, life-long learning opportunities, and social innovation [20, 21].

Such policies are effective, however only on stakeholders involved in the educational system [22] [Europa Eu: European Education Area for Environmental Sustainability https://ec.europa.eu/education/education-in-the-eu/european-education-area/education-for-environmental-sustainability_en].

Large parts of the population remain strangers both to sustainability aspects and their own active role on circular bioeconomy [23]. As circular bioeconomy matured, a need for citizen participation and activation was recognized as a major market and society drive. The required mentality shift was even compared to the Agricultural and Industrial Revolutions in radicality [10]. It introduces "People and Society" as a system variable that affects the market, and consequently the success level of overall sustainability through its "needs and demand for new products" (Fig. 1). Steps towards citizen awareness and participation have been taken and are in some cases fruitful, for example in concepts like sustainability, gas emissions, and recycling, while in others, there is still much room for improvement.

Waste is still considered waste for the public [24]. But for circular bioeconomy, it is a valuable asset [25]. Waste perception is a setback for many applications concerning skincare products, for example, to be created by by-product streams. Transforming "waste" to "resource" in an average consumer's mind can be a long process, but it can possibly create the

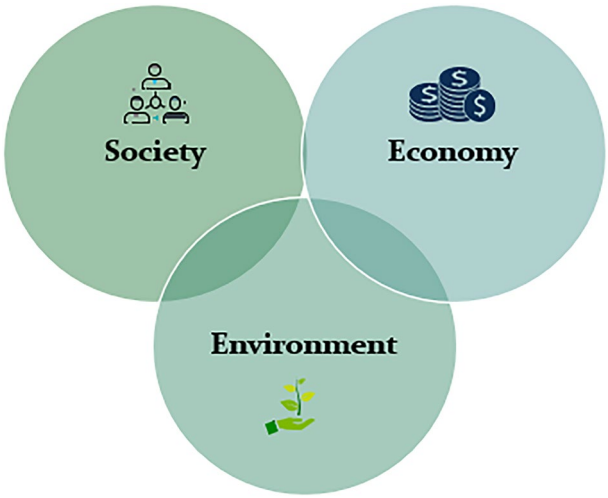

Fig. 1 The interaction between the economy, society, and the environment

mindset-market shift we need to valorize biomass on its whole, when this is possible. Why are current policies still failing to trigger this mentality shift?

Assessment of Current Methodologies for People Awareness Aligned to the EU Directives

With educational institutions and the industry being considered the main drive for awareness, circular bioeconomy remains unapproachable. Events, dialogues, virtual or real, idea expression, and good practices exchange are only good within the academic and market circles.

From an economic point of view, "offer" is centrally regulated by legislation while "demand" can only change through awareness. While in some product categories, citizens tend to prefer more sustainable solutions (ex. sustainable crops), other categories keep customers skeptical if the primary resources are labeled as "waste" (ex. cosmetics or food created by agro-residuals).

Training responsible consumers is one side of the coin where education and awareness campaigns play, indeed, an important role. But to reach a mentality shift and activation, it requires deeper knowledge stemming from hands-on experience. Encouraging personal experience and engagement on circular bioeconomy can work both as a wide educational tool and market multiplier. There are multiple levels to do this. In this paper, urban citizen activation through internet technologies and citizen science is suggested. The proposed application field concerns the urban region of Attica where bitter orange trees produce large quantities of citrus waste.

The Aim of This Paper

This paper aims to showcase that within the circular bioeconomy and environmental concepts, problems arising are closer than we imagine. The media is not giving the true dimension of environmental issues that have reached our front yard. Thus, the big

difference will occur more through citizen activation and participation than law enforcement. Unfortunately, results are not visible in all cases, making it difficult for the masses to perceive and act. At this point, symbolic rewarding of people's participation is crucial to educate society on biomass value. This case study examines the non-edible citrus biomass encountered in many Mediterranean cities. In a wider perspective, the proposal could be used in similar circular bioeconomy–related activities requiring citizen participation.

Living and Consuming in Urban Areas

This paper focuses on the awareness of urban areas because of the demographics and modern lifestyle of people populating them. With a hectic schedule, long working hours, and distances and traffic consuming a large part of their day, people are looking for the easiest and fastest solutions possible to deal with everyday needs such as consumption, food, and cleaning. Internet access saves time and money and provides countless virtual product options. In this context, environmental activation seems rather a luxury than necessity, despite the fact that an overall majority of EU citizens think of environmental issues, climate change, and harmful chemicals in everyday consumption goods as a hurdle to be tackled by changing the way we produce, consume, and trade [Eurobarometer Survey (2019)]. However, municipal solid wastes (household waste) surveys tell a different story with industry being unable to recycle them due to heavy contamination [European Environment Agency (2019) Waste recycling in Europe https://www.eea.europa.eu/data-and-maps/indicators/waste-recycling-1/assessment-1. Accessed 13 November 2021]. While recycling is a relatively well-communicated issue on circular economy, people still find it hard to clean their waste before placing it in the recycling bin. With circular bioeconomy still being a niche for academia and the industry, how could citizens possibly participate [26]? Detachment from nature is another result of heavy urbanization and crucial for bioeconomy. Summing up all the characteristics of the urban population to form a proposal, it is safe to say people in the cities are prone to impulsive and fast consumption and living, have a rather high dependence on mobile technology, and have limited free time to devote to learning new skills not directly linked to their benefit [27].

The Urban Areas Are Huge Resources of Valuable Biomass

Urban citizen activation approaches align with EU demographics. The twenty-first century society is mainly influenced by urban areas. The U.N. data predicts that by 2050, approximately 70% of the population will live in urban centers, increasing environmental concerns since they do not always grow sustainably [28]. This population density is very important both for targeting awareness campaigns and for biomass concentration. Urban environments can in fact be a great source of biomass [29] whether municipal or household. Municipal biomass from tree pruning alone can be used for renewable energy purposes. Managing to mobilize a substantial part of the population would make a huge difference for the recycled-renewable material flows.

The Significance of Urban Awareness

The urban social and environmental ecosystem can become a great opportunity for circular bioeconomy. Both in terms of population density and biomass concentration, the potential is huge. Communication, education, and environmental labor skill enhancement are important, but it would be interesting to examine the effect of culture and lifestyle in people's mobilization to collect this biomass themselves. Internet could provide a solution in this regard especially when looking into the extensive use of social media among urban users.

Current Urban Lifestyle and Social Media

The average time spent online, given the limited amount of time people are willing to spend on environmental protection activities like recycling material sorting, can be a source of inspiration for participation optimization methodologies [25]. Social media application characteristics cover core people's needs—socializing, connecting, feeling important while comparing yourself with others, curiosity, excitement with providing unlimited amounts of information, and of course, easy accessibility [30]. If we also consider the Covid-19 crisis of the previous year, social media interaction has replaced a large part of physical interaction making mobile addiction even worse. Incorporating social media features in citizen science could bring circular bioeconomy concepts closer to the average consumer in a more approachable way [31].

Existing Examples of Applications Designed for Urban Citizens Activation and Rewarding Systems

Initiatives to activate citizens are gaining more and more ground whether they involve rewarding motivation or not. Most of them concern plastic recovery and recycling. Indicatively, we will mention four examples:

Italian initiatives also propose tax rewarded door-to-door recycling methods to increase citizen participation. Smart technologies are used to scan and sort the material while citizens can monitor the course of the material they recycled through a dedicated mobile application [32].

The RecyclingToCoin initiative had launched in the United Kingdom (UK) in 2017 and was the first to introduce cryptocurrency rewarding for the collection of plastic bottles and aluminum cans. It rewards users whenever they make a deposit at cooperating collecting points with digital currency and eGift cards. A QR code is scanned per deposit and the equivalent reward can be turned into Bitcoin, Ether an eGift (cooperation with GiftPay), or a donation to Plastic Bank, to support fighting poverty and pollution globally. The application is supported by the Global Plastic Offset Scheme who works toward recycling motivation [33].

On the other hand, UK's Scrapp aims to simplify recycling by scanning packaging and letting the users know which is recyclable. Users gain bonus point for recycling and use them as discounts in shops embedded in the app. This way, they help people who found recycling confusing, and they sort plastic that otherwise would be misplaced

and reduce landfill fees [Packaging Europe: Newly released app aims to simplify and reward recycling: https://packagingeurope.com/newly-released-app-aims-to-simplify-and-reward-recycling/].

Spain's PlastiCircle also rewards citizens for correct recycling habits through specific smartbins, but this time without the use of a mobile application [Europa EU: https://ec.europa.eu/research-and-innovation/en/horizon-magazine/smart-containers-reward-people-recycling-properly].

Other interesting citizen science and awareness activities, who however do not include rewarding systems, are the Plastic Pirates-Go Europe (Germany, Portugal, Slovenia) and APPLAUSE (Ljubljana). The Plastic Pirates [Plastic Pirates: Go Europe!: https://www.plastic-pirates.eu/en] want to raise awareness about plastic waste ending up in rivers and finally to the ocean. Schools of this international program are involved by gathering plastic from the riverbanks and then reporting the material found in a common data base. This way, research is enhanced regarding the plastic pollution issue at its root. On the other hand, APPLAUSE aims to raise awareness on alien plant species that threat local flora. Those species are identified through a mobile application by citizens, are collected, and then use in applications like food coloring, paper, and liquid wood [UIA Initiative, Cities, Ljubljana: https://www.uia-initiative.eu/en/uia-cities/ljubljana].

Demand for Appropriate Infrastructure

Wide smartphone use has largely democratized access to knowledge. But is this enough to educate people for circular bioeconomy? Optimization of mobile sustainability–related applications to cover basic human needs like communication, achievement, or rewarding [30] is only one sided. Making the process easy and approachable is also very important in response to the urban lifestyle.

Participation in biomass collection requires spatial organization in key collection points. Let's borrow the paradigm of recycling smart bins. For measurement and data collection purposes, ICTs must be included.

They are an advanced technological tool that can facilitate the transit towards smart city networks. Smart cities can provide realistic urban data collection and analysis using "software systems, server substructure, network infrastructure, and client devices" [34]. With a series of technological infrastructure like sensors, actuators, and mobile devices instrumented and interconnected, a wide variety of solutions and public services can be provided. With such a "smart" environment, information exchange between municipalities, businesses, and citizens becomes highly accessible [35].

Intelligent network systems embedded at a municipal level would increase smart bin accessibility, thus making contribution easier [17, 31]. Plus, real-time collection data would help assess the amount of bio-material deposited. It would be better monitored and managed with smart transportation systems connected to each smart bin. By the time a certain weight of material reached the limit, sensors would signal specific transportation centers, or underground channels, and would be collected accordingly [19]. This can also increase the efficiency in material transportation resulting in fuel savings since the smart bin would only be emptied when full. For biomass/organic waste collection, details like heat and fermentation levels can also be measured [26, 28] [(2021) Smart cities. In: European Commission. https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en. Accessed 8 Jul 2021].

Despite EU's encouragement for ICT's integration, the legal framework remains complex and is highly dependent on local adaptation [23] [In European Smart Cities: http://www.smart-cities.eu/ranking.html]. In a ranking for 70 European cities, in Athens, where the case study to follow takes place, there is no mention in the chart. Presumably, more action must be taken on behalf of local municipalities to adapt to European standards regarding smart cities and the green economy prospects that accompany them [36, 37].

Ways to Promote Natural-Based Solutions in Urban Areas

People in urban areas experience distancing from nature, which largely makes education on circular bioeconomy difficult. Hands-on experience, like the collection of biomass combined with ICT facilitation, could be an interesting case study to actively involve people in the process. Active involvement with the natural urban environment can have other benefits on the residents too, like stress relief, socializing, and a feeling of achievement and solidarity to the community as indicated by the case studies of "municipal gardening" [38].

Mobile applications recruitment, on the other hand, can make people understand that going green doesn't always require much time, dedication, monetary contribution, or even a master's degree on circular bioeconomy. Technology has now the power to make gradually make people's lives more sustainable and greener [39].

Rewarding citizens for biomass collection is a very interesting proposal [40]. Rewarded recycling achieved an increase of 35% in the amount of material recycled in o Windsor and Maidenhead's scheme in the UK, while an 80–90% of citizens participated even without accepting rewards [41]. Exploring the nature and role of motives in decision-making and participation would provide us with valuable information and could change the way we approach awareness campaigns. Other studies indicate that random rewarding methods, like online lotteries, have even better results of participation.

The Bitter Orange Problem in Attica, Greece

The urban area of Attica in Greece could work as a great potential case study for the implementation of citizen science in circular bioeconomy. Athens is home for more than 100,000 bitter orange trees since the nineteenth century.

This particular tree variety has been chosen to decorate the city thanks to its urban-friendly behavior. Bitter orange trees, or "*neranjia*," as it is called in Greek, are particularly resilient and easily adaptable to the Mediterranean climate. This statement can be supported by the simple observation that similar trees can be easily encountered in the European South. Its resilience and stability make it ideal for city environments where the cost for green maintenance and restoration needs to be suppressed to the minimum. Bitter orange trees do not require compost, chemical treatment for parasites, or too much water to grow. Its dense and dark green foliage assists in enhancing the green presence in the city and meliorating microclimatic conditions such as temperature and shading during the summer, and air quality. In addition, a big advantage of this tree is its symmetrical growth [University of Arizona Campus Arboretum (2012) Citrus aurantium, Find Trees & Learn. In: Arizona.edu. https://apps.cals.arizona.edu/arboretum/taxon.aspx?id=76. Accessed 10 Jul 2021]. Unlike other citrus trees like lemon trees, a bitter orange tree's growth rate and shape can be easily predicted which is a very useful trait in terms of architectural and urban

planning. Another trait of this tree is its beautiful, colorful appearance during fruition and delightful smell during blooming in spring. This reinforces the esthetic appearance of the city and has been praised by many Greek artists and poets, even featuring the tree in folk songs.

Despite its undisputed advantages, bitter orange also comes with many disadvantages that require serious action. Bitter orange is overall a non-edible fruit. Standing for its name, it is so bitter that it's impossible to eat raw.

In a long discussion about food security and supply in urban areas under the pressure of climate change and limited cultivation areas, bitter orange would be ideal, if edible, especially for Greece, where urban agriculture could be a solution for unemployment after the economic crisis. As a result, people have no direct reason to collect fruit for consumption. In an attempt to make the fruit edible, few local authorities have attempted to graft the trees by mixing them with orange or lemon varieties, however with little success. Others have tried replacing the trees with olive trees but in this way, they have sacrificed much more since olive trees have deep, tangling roots, unpredictable growth, and fruits easily affected by city gas emissions and pollution leaving a bad smell behind.

Regarding proposals to use this feedstock as animal feed, opposite to other citrus varieties used for the same cause, bitter orange would not be an ideal choice. Due to its acidity, it can't be used as feed in large quantities, though it can be beneficial when used as a supplement [42]. The acidity of the fruit is also the reason why it is rather difficult to compost [43]. Despite its difficulty, efforts to use it as compost have been made by municipal authorities. But other than that, the governmental involvement is too little to systematically resolve the issue.

So far, Athens is left with a fruit that cannot be used in any of the most common applications; thus, there is no direct motive for people or the authorities to collect it. And not only that but it is also estimated that 40,000 tons of bitter oranges end up on the streets each year. This huge mass of overly mature fruit rotting on the street can result in accidents, vehicle damage, clogged rainwater drainers, and acidity in water treatment facilities. All the above can only be translated into a huge cost for the municipal authorities. With the fruit scattered around the city, collection would result in extensive municipal costs, with minimum profound earnings, at least regarding the food, feed, and composting industries.

Citizen Motivation and Engagement

Apart from the above industries, it's interesting to see alternative uses for this biomass that could possibly make bitter orange worth using. However, the novelty we propose is that there is a wide range of materials we can retrieve before biofuels, such as citrus oil, bioflavonoids, citrus seed extract, petitgrain dry extract, juice, and citrus peel pellets [44–46]. And in most cases, those materials can have a higher yield in profits too. Some of those materials can be included in end products like cosmetics, detergents, biocomposite materials, and food and feed supplements [47, 48].

Unfortunately, the vast majority of citizens are unaware of the bitter orange biomass potential. The biggest setback for biomass valorization in this case is no other than the common misbelief that if we cannot eat, or compost a certain fruit, then it is useless. This misbelief is attributed to the lack of social awareness not only at the civilian level but also at the political and decision-making level. For this reason, it's important to develop ways to introduce citizen science methodologies in a way that engages

as many stakeholders as possible. People could in fact play an active role of gathering bitter orange themselves, while authorities could endorse awareness and involve local communities to participate. Other stakeholders like local shops can also be involved to enhance their social responsibility status. In inclusive methodologies, dissemination of knowledge, awareness and participation, and sustainability-related projects could be very fruitful.

A Collection and Rewarding System

We will now make a short description of a bitter orange collection and rewarding system that aims to include all 3 major stakeholders: citizens, authorities, and market players. The main idea is to let people participate in the collection of bitter orange and get rewarded according to their performance. People will have a free Bitter Orange application on their smartphones (Fig. 2).

The app looks like a game and provides useful information in the form of daily tasks and notifications like the "start of the bitter orange harvesting season" when people can start collecting bitter orange. Bitter orange will be collected in special reusable bags of 5 kg maximum, to facilitate physical transportation, and put it in smart bins connected to their application. The bin will automatically weigh the fruit while connected to the mobile application through delicate sensors [49, 50] and add bonuses to each person's profile according to their performance on the "Bitter Orange Hunting-HARVESTING." The bin will also estimate the total weight of biomass and notifies the material recycling company to empty them. By participating in the program, people will get rewarded with bonus points that will be used as discounts and offers on local shops and services associating with the program. Municipalities could also participate and assist by holding events and disseminating information and awareness about the project.

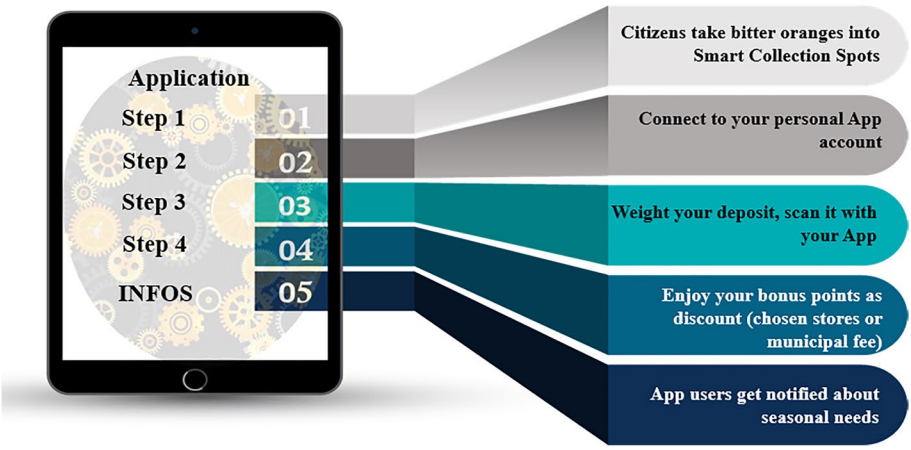

Fig. 2 Description of the "Bitter Orange Project" application functionality

Benefits of Participatory Collection

This can resolve a major problem related to the bitter orange collection and valorization. One of those is that the fruit is scattered all around the city. Collection would be an expense for municipalities, plus the energy inefficiency of transportation with hired tracks. In Seville, Spain, collection of bitter orange is conducted by special tracks that "hug" the tree and shake it until it drops the fruit. The fruit falls in the umbrella and used as bio-energy feedstock. We will lately refer in detail to this case study and its flaws. The collection process alone is efficient, but it excludes society and any awareness benefits from people's personal experience with a natural treasure, biomass. Simplifying collection would possibly increase efficiency if we were interested solely in an industrial exploitation. But this could be in fact an interesting case study for motivated participation in biomass collection in the footsteps of widely recyclable materials.

Another benefit of the "Bitter Orange Project" proposal is urban herbal waste awareness. People don't realize that waste does not necessarily come from human activity. In urban areas, biomass accumulation is way faster with minimum potential for absorption in comparison to natural environments; thus, the excess biomass becomes waste.

This "waste" needs not only to be collected, but also to be considered "a bio-resource." When people get rewarded by gathering bitter orange, then this biomass is being associated with value. Hopefully, through this process, herbal waste starts being considered more of an opportunity, a resource to take advantage of rather than unwanted waste. People are expected to observe their surroundings more and notice different types of waste, other than the household generated.

Education on new natural ingredients through the mobile application can also enhance this association to value. Through their smartphone, people could get informed about how the bitter orange they collected was used and what ingredients where produced out of it. By encouraging knowledge on natural ingredients like bioflavonoids, which are antioxidants resulting in enhanced vitamin C action, allergy and virus treatment, better blood circulation, and reduce risk of heart diseases [51, 52], we can also have a positive effect on people's health and help them turn to natural solutions. With natural ingredients' importance becoming a largely discussed topic, especially after the Covid-19 crisis [53].

Additional Aspects of Rewarding

Direct rewarding is just one aspect of the citizen activation methodology [54]. Rewarding can also receive other forms depending on the motives that trigger each person to participate. Benefits and a feeling of content associated with social network characteristic or with gaming would also be interesting to investigate and possibly incorporate into the application.

Each user could connect to his/her network in the application, friends, colleagues, and relatives, and compete with them on bitter orange collection performance. The winner could get extra bonuses together with the benefits of socializing and having fun.

What Motives We Would Like to Test for Participation Efficiency

Through a mobile application, we could gather data for different participation motives and their contribution into activation of citizens. The two main parameters we could check and collect data for are as follows:

- Symbolic monetary rewarding—the element of excitement that comes with an extra reward could make a difference. For a bonus system that translates into discounts, corporate social responsibility players play a major role by redeeming points for actual products or services. In this case, not only does a network of environmental performers simply recognize a person as a "good player," but society provides a handful of rewards as well. Through the app, the "bonus point" to "discount shopping" in specific product and service codes could show how many of those participating truly use the benefit offered to them.
- Competition—competition and satisfaction related to winning is a very powerful human drive as it sparks confidence, social importance, and recognition and as a result, is expected to stimulate participation. Comparing one's environmental performance with their social network could make a person exceed the digital environment of an application and bring an impact to the physical world. Comparison can this way bring added value not only to the person that simply wants to be the best, but also to the environment through active encouragement. The effect of competition to citizen activation could be measured by adding "daily challenges" among users and see how they respond.

There are also other indirect rewarding motives that could affect the result. However, those are difficult to assess and would require qualitative data like questionnaires. The application could from time to time send users such questionnaires and reward answering with extra bonus points. Those are the following:

- Entertainment—making an application look and function like a game allows to embed carefree knowledge, provided at any time and in a playful way. Toddlers learn by playing. Getting older the knowledge and skills acquisition methods lose this element but, it remains one of the most effective ways to learn. Because it looks easy, it motivates us to participate, it generates experience, and it is pleasant [55].
- Ethical rewarding—as stated before [41], people often simply want to know that they do the right thing. This means that just recognition from the community as a "responsible citizen" is enough. Municipalities could be help in this case by announcing the best performing players through their social media and webpage, if the users agree to the publication.
- Accessibility—the free of charge use of the application ensures accessibility, at least for people owning a smartphone. Democratizing the chance to environmental excellence and offering actual rewards for it is a proposal worth experimenting with.
- Socializing—by definition, interaction with a person's network through an application indicates some level of socialization. However, since the aim of this project is to get people on the street, it would be interesting to check web-untraceable externalities like socializing in person in order to gather bitter orange.

A Pilot Proposal and Added Value Chain

Getting people to participate in bitter orange collection through a mobile application can be very challenging itself. The data collection and assessment gained by users undoubtedly demands a lot of trial and error to identify what motives work in an activating way. We are also aware that other factors, like different demographic data for each municipality (age

groups, economic status), could reflect different motives as driving forces for participation. For a pilot testing of the project, it would be proposed to examine more closely the direct rewarding in form of bonus points. This system has been used before for conventional recycling materials with a certain amount of success. Thus, it is expected to contribute in a positive way and forms the first hypothesis: "When rewarded, people participate more."

In what concerns citrus biomass, it has deferent prerequisites than typical recyclable materials since it is susceptible to decay, seasonality, and weather conditions. More or less Attica produces 40 k tones of bitter orange each year, and with the particular variety being stable in Mediterranean climatic conditions, we can safely say that biomass supply is rather safe and allows to scale up. Before gradually scaling up though, it would be better to run the project in one or two municipalities to test how we could better manage small quantity bitter orange streams.

From those small streams, we can make safer conclusions of the products that could be generated. So far, this paper hasn't largely focused on this, rather on the citizen activation part. Bibliography, and our laboratory testing, has shown promising materials (citrus oil, bioflavonoids, citrus seed extract, petitgrain dry extract, juice, and citrus peel pellets) [44–46] deriving from bitter orange. While the market for those materials is promising, pilot scale application could show very different results and by-products. By-products like peel mold and juice could also be valorized into other applications worth exploring, for example biocomposite materials and bio-plastic. A pilot scale project would provide with more accurate data on the quantities of both products and by-products generated and their suitable applications on potent scale-up.

An Industrial Perspective

The Bitter Orange Project application in Attica could have a multiplying effect for the wider Mediterranean area, where not only bitter orange, but other citrus varieties are prevailing. Citrus is very common in the South, and so are the problems arising when it is not properly exploited. That's why cities like Seville (see example below) are taking action to find a use for them. Overproduction in rural areas also often ends up in rotting cultivation when the market needs are not met. Raising awareness on herbal waste worth could also result in increased interest in finding alternative applications for farmers as well.

The picture and the growth potential widen if we consider that such a model could be applied beyond Attica. For this reason, pilot scale production units are mandatory both to define exact product volumes and to gradually overcome by-product-related issues that will inevitably occur while scaling up. For a start, small pre-processing units will be necessary. There, a first material sorting will occur, and then, the useful high value material could be send to more central collecting points for further processing. This can result in more resilient and lightweight biomass (in case excess water is removed), easier transportation and biomass management, as well as minimized operational costs for many full-scale production units. If applied successfully in Greece, regional Mediterranean processing centers should also be examined. The same logic is used for recyclable plastic sorting.

In bioeconomy activities scaling, undisrupted material streams for an unstable resource are always a big challenge. The above proposal refers mostly to raw material collection and sorting. The products resulting from this raw material are a whole new ground for experimentation since they could be used both as intermediate and end products in various applications. From our preliminary research, we have detected up to 11 different products

deriving from different parts of the fruit (peels, seeds, leaves, juice). However, it is impossible to estimate exact product volumes unless pilot scale testing are conducted first.

Similar Initiatives in Europe

Around Europe, interest for biomass exploitation is growing fast and so are the applications. We will shortly look into some similar initiatives in Europe.

Seville

The city faces problems similar to Attica's regarding the bitter orange biomass ending up on the street. The municipal authorities have decided to tackle the problem by collecting bitter orange in specific tracks and turning it into energy to power with electricity local households. This initiative is one step closer to the circular bioeconomy way of thinking but lacks optimization regarding the end use of the biomass [Burgen, S (2021), A Role Model': How Seville Is Turning Leftover Oranges into Electricity, The Guardian, 2021, https://www.theguardian.com/environment/2021/feb/23/how-seville-is-turning-leftover-oranges-into-electricity. Accessed 8 Dec 2021].

In the "bioeconomy terminology," we are often referred to as the 4Fs. The acronym stands for Food, Feed, Fibers, Fuel [56, 57]. This gives us a simplified range of the applications of biomass but also a defined prioritization according to the hierarchy of the human needs that are also implied by the numbering of U.N. Sustainability Goals. Meaning that

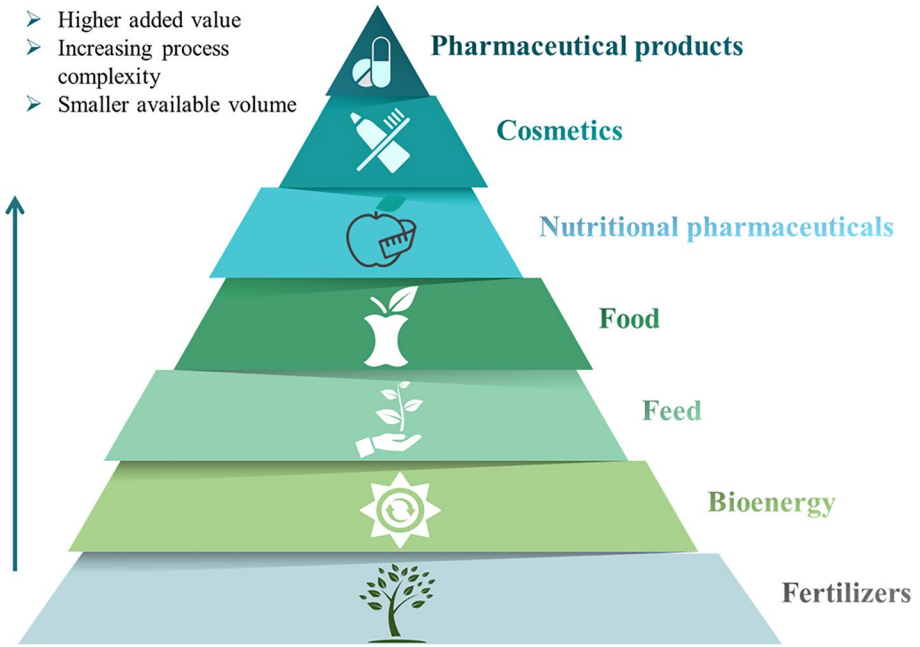

Fig. 3 The pyramid depicting the inverse ratio of volumes and added value bio-products

food and feed security always comes first, followed by the need to secure materials (fibers), and finally energy (fuel).

Why is energy put last? Simply because once we burn biomass, it is impossible to recover it. We must first strip away all valuable materials ranking in the prioritization chart before turning the leftovers into energy. A more reasonable way of thinking would see how bitter orange derivatives could be used in one of the 4F's ranking higher in the priority hierarchy. In option 1, food is not eligible for bitter orange. Regarding option 2 (feed), it could be used as a feed supplement. However, the processing is necessary for this cause [58]. Fibers (and other materials) however present a large field of application. Some of the relevant industries include cosmetics, agriculture protection, natural detergents, etc. (Fig. 3).

Italy

In our neighbor country, Italy, leftover orange peels from the fruit processing are turned into fabric. This is in fact a sustainable and versatile material since it can be used sole or mixed with other materials to create the desired fabric properties and feeling. This example shows the potential of citrus fruit by-products and their impact on the environment. The fashion industry is extremely polluting and resource inefficient. It takes 20 k L of water to produce just 1 kg of cotton. If we manage to incorporate sustainable, by-product resources widely available from other industries (or urban waste in our case), this can make a huge impact in our planet and well-being [Rajal Pankti (2020), Future of Fashion: Innovative Fabric—Orange Fibre, Amberoot: https://amberoot.com/blogs/blog/future-of-fashion-innovative-fabric-orange-fibre, Accessed: 10 Dec 2021].

The Netherlands, PeelPioneers

PeelPioneers, on the other hand, is the largest European Processing facility for orange peels deriving from fresh orange juice production in supermarkets, hotels, and restaurants. The peels produce a series of products that can be used in the food industry. For example dietary fibers for meat substitutes, bakery products, and sauces (assisting this way the protein transition) orange oil, and other raw materials that are in high demand in the food additives sector, but also in the detergents and cosmetics industries. As both private and public investors are supportive of the initiative, the team is scaling fast and plans to install 5 more facilities around Europe within the next 5 years. This paradigm also shows interest in reusing citrus waste, plus that technology is gradually maturing. For this reason, effective collection systems of citrus become more and more necessary [In PeelPioneers: Circular scale-up PeelPioneers builds the largest peel factory in Europe, https://peelpioneers.nl/nieuws/2020/10/2/circular-scale-up-peelpioneers-builds-the-largest-peel-factory-in-europe-etm4r].

Future Perspectives

Efficiency matters. However, we have witnessed that in the previous years, industry and highly skilled labor force have been the main drives for bioeconomy. PeelPioneers have taken a step further and have reached out to retail, food chains, and hotels. Market players that have seemingly little awareness on bioeconomy. The next step would be to approach citizens themselves and rewarding would worth being examined as a means of motivation.

In this sense, Attica's bitter orange citizen activation proposal could be a prototype platform that can be used for other cases of organic urban waste management. Numerous studies address approaches to the green and sustainable separation of natural products from waste biomass, such as coffee grounds, other fruit, and vegetable residues [59], or wine by-products [60]. Other examples include cooking oils [61] and leftovers from garden pruning [28]. Engagement of civilians and the creation of social awareness through all the above activities should be a priority if we wish to see larger participation in bioeconomy within the next years.

Conclusion

We are witnessing a point where Earth's climatic and environmental changes are visible and more frequently repeated compared to our prior acquired knowledge. Society is not ready to design and implement large-scale schemes for protection and inhibition. This is more of a political matter where society could pressure policy adoption. In everyday life, each citizen can contribute through small, cost-free actions. The only prerequisites are a mentality shift and the devotion of personal time, which can be short, but consistent. As a result, constant information, gradual training, and rewards come as a priority. This study identifies a tangible problem of citrus waste in Attica, and proposes a solution where activation is visible both to the person and the society. Citizen power lies in mass activation and continuity regarding environmental issues.

Abbreviations ICTs: Information and Communication Technologies; EU: European Union; U.N.: United Nations; SDGs: Sustainable Development Goals; UK: United Kingdom; 4Fs: Food, Feed, Fibers, Fuel

Author Contribution All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Menelaos Neofotistos, Nafsika Hanioti, Eleni Kefalonitou, and Konstantinos E. Vorgias. The first draft of the manuscript was written by Anastasia Z. Perouli and Nafsika Hanioti and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data Availability Not applicable.

Code Availability Not applicable.

Declarations

Conflict of Interest On behalf of all authors, the corresponding author declares no competing interests.

References

1. Shahriar Shafiee and ErkanTopal (2009) When will fossil fuel reserves be diminished? Energy Policy 37(1):181–189. https://doi.org/10.1016/j.enpol.2008.08.016
2. Cecchin A, Salomone R, Deutz P et al (2021) What is in a name? The rising star of the circular economy as a resource-related concept for sustainable development. Circ Econ Sust 1:83–97. https://doi.org/10.1007/s43615-021-00021-4
3. European Commission (2020) A European Green Deal. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en. Accessed 18 Dec 2021
4. European Commission (2019) Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social committee and the Committee of the Regions: The European Green Deal: Brussels, 11.12.2019 COM(2019) 640 final

5. Gigliotti M, Schmidt-Traub G, Bastianoni S (2019) The Sustainable Development Goals. Encyclopedia of Ecology (Second Edition) 4:426–431. https://doi.org/10.1016/B978-0-12-409548-9.10986-8
6. Nikolaou IE, Jones N, Stefanakis A (2021) Circular economy and sustainability: the past, the present and the future directions. Circ Econ Sust 1:1–20. https://doi.org/10.1007/s43615-021-00030-3
7. Kirchherr J., Reike D., Hekkert M. (2017) Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling (ELSEVIER) 127:221–232. https://www.sciencedirect.com/science/article/pii/S0921344917302835
8. Franco-García ML., Carpio-Aguilar J.C., Bressers H. (2019) Towards zero waste, circular economy boost: waste to resources. In: Franco-García ML., Carpio-Aguilar J., Bressers H. (eds) Towards Zero Waste. Greening of Industry Networks Studies, vol 6. Springer, Cham. https://doi.org/10.1007/978-3-319-92931-6_1
9. Glossary of Statistical Terms: Biological resources (2005) Stats.OECD. https://stats.oecd.org/glossary/detail.asp?ID=6359. Accessed 18 Dec 2021
10. Birner R. (2018) Bioeconomy concepts. In: Lewandowski I. (eds) Bioeconomy. Springer, Cham. https://doi.org/10.1007/978-3-319-68152-8_3
11. Venkatesh, G. (2021) Circular bio-economy—paradigm for the future: systematic review of scientific journal publications from 2015 to 2021. Circ.Econ.Sust. https://doi.org/10.1007/s43615-021-00084-3
12. Stegmann P, Londo M, Junginger M (2020) The circular bioeconomy: its elements and role in European bioeconomy clusters. Resources, Conservation & Recycling: X 6:100029. https://doi.org/10.1016/j.rcrx.2019.100029
13. Tobias Heimann (2019) Bioeconomy and Sustainable Development Goals (SDGs): does the bioeconomy support the achievement of the SDGs? Earth's Future 7(1). https://doi.org/10.1029/2018EF001014
14. Suárez-Eiroa B, Fernández E, Méndez-Martínez G, Soto-Oñate D (2019) Operational principles of circular economy for sustainable development: linking theory and practice. J Clean Prod 214:952–961. https://doi.org/10.1016/j.jclepro.2018.12.271
15. European Commission (2018) A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment (Updated Bioeconomy Strategy). Strategy, Directorate-General for Research and Innovation, Brussels: European Commission. https://op.europa.eu/en/publication-detail/-/publication/edace3e3-e189-11e8-b690-01aa75ed71a1/language-en/format-PDF/source-149755478
16. Duque-Acevedo M, Belmonte-Ureña LJ, Yakovleva N, Camacho-Ferre F (2020) Analysis of the circular economic production models and their approach in agriculture and agricultural waste biomass management. Int J Environ Res Public Health 17:9549. https://doi.org/10.3390/ijerph17249549
17. Bueno-Delgado M-V, Romero-Gázquez J-L, Jiménez P, Pavón-Mariño P (2019) Optimal Path Planning for Selective Waste Collection in Smart Cities. Sensors 19:1973. https://doi.org/10.3390/s19091973
18. EU waste management law (2020) In: Europa.eu. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:ev0010&from=EN. Accessed 9 Jul 2021
19. Kirilyuk M, Mayer M, Simons T.J, Witte C (2020) The European recycling landscape—the quiet before the storm? In: McKinsey & Company. https://www.mckinsey.com/industries/chemicals/our-insights/the-european-recycling-landscape-the-quiet-before-the-storm. Accessed 8 Jul 2021
20. European Commission (2020) Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social committee and the Committee of the Regions: A new Circular Economy Action Plan For a cleaner and more competitive Europe In: Europa.eu. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0098&from=EN. Accessed 9 Jul 2021
21. Pardini K, Rodrigues JJPC, Diallo O, Das AK, de Albuquerque VHC, Kozlov SA (2020) A smart waste management solution geared towards citizens. Sensors 20:2380. https://doi.org/10.3390/s20082380
22. Sarti M., St. John S.K. (2019) Raising Long-Term Awareness: EU Environmental Policy and Education. In: St. John S., Murphy M. (eds) Education and Public Policy in the European Union. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-04230-1_8
23. Baisa B, Buljat B, Babić A, Čapko Z, Gaspari F, Hruza F, Volčik S, Janurova M, Chaloupkova M, Kašćelan L, Filipović L, Ana NB, Milijana KV, Makyšova L, Maravić D, Pezo H, Samaržija L, Pivar J, Rikalović G, Josipović S (2020) Smart governments, regions and cities. University of Rijeka, Faculty of Economics and Business
24. Gay Hawkins (2006) The Ethics of Waste: How We Relate to Rubbish. Rowman & Littlefield Publishers
25. Østertun Geirdal A, Ruffolo M, Leung J, Thygesen H, Price D, Bonsaksen T, Schoultz M (2021) Mental health, quality of life, wellbeing, loneliness and use of social media in a time of social distancing

during the COVID-19 outbreak. A cross-country comparative study, In: Journal of Mental Health 30(2):148–155. https://doi.org/10.1080/09638237.2021.1875413
26. Ferrara R (2015) The Smart City and the Green Economy in Europe: A Critical Approach. Energies 8:4724–4734. https://doi.org/10.3390/en8064724
27. Turel O, Brevers D, Bechara A (2018) Time distortion when users at-risk for social media addiction engage in non-social media tasks. J Psychiatr Res 97:84–88. https://doi.org/10.1016/j.jpsychires.2017.11.014
28. Knickmeyer D (2020) Social factors influencing household waste separation: a literature review on good practices to improve the recycling performance of urban areas. J Clean Prod 245:118605. https://doi.org/10.1016/j.jclepro.2019.118605
29. Springer TL (2012) Biomass yield from an urban landscape. Biomass Bioenerg 37:82–87. https://doi.org/10.1016/j.biombioe.2011.12.029
30. Zhen F, Wei Z (2008) Influence of information technology on social spatial behaviors of urban residents — Case of Nanjing City in China. Chin Geogr Sci 18:316–322. https://doi.org/10.1007/s11769-008-0316-x
31. Mavropoulos A, Tsakona M, Anthouli A (2015) Urban waste management and the mobile challenge. Waste Management & Research: The Journal for a Sustainable Circular Economy 33:381–387. https://doi.org/10.1177/0734242x15573819
32. L. Pelonero, A. Fornaia and E. Tramontana (2020) From Smart City to Smart Citizen: Rewarding Waste Recycle by Designing a Data-Centric IoT based Garbage Collection Service. IEEE International Conference on Smart Computing (SMARTCOMP). 380–385. https://doi.org/10.1109/SMARTCOMP50058.2020.00081. https://ieeexplore.ieee.org/abstract/document/9239615
33. (2018) App encourages consumers to recycle by offering rewards. Springwise. https://www.springwise.com/app-encourages-consumers-recycle-offering-rewards/. Accessed 18 June 2021.
34. Novotný R, Kuchta R, Kadlec J (2014) Issue 2 • 1000117 J Telecommun Syst Manage ISSN: 2167–0919 JTSM, an open access journal Novotný et. Applications and Services J Telecommun Syst Manage 3:117
35. Singh A (2021) Indicators and ICTs application for municipal waste management. Waste Management & Research: The Journal for a Sustainable Circular Economy 0734242X2110103 . https://doi.org/10.1177/0734242x211010367
36. de Souza V, Melaré A, Montenegro González S, Faceli K, Casadei V (2017) Technologies and decision support systems to aid solid-waste management: a systematic review. Waste Manage 59:567–584. https://doi.org/10.1016/j.wasman.2016.10.045
37. Bampidis VA, Robinson PH (2006) Citrus by-products as ruminant feeds: A review. Anim Feed Sci Technol 128:175–217. https://doi.org/10.1016/j.anifeedsci.2005.12.002
38. Stefanakis AI, Calheiros CS, Nikolaou I (2021) Nature-Based Solutions as a Tool in the New Circular Economic Model for Climate Change Adaptation. Circ Econ Sust 1:303–318. https://doi.org/10.1007/s43615-021-00022-3
39. Triantafyllidou, E., Zabaniotou, A. (2021) Digital Technology and Social Innovation Promoting a Green Citizenship: Development of the "Go Sustainable Living" Digital Application. Circ.Econ.Sust.. https://doi.org/10.1007/s43615-021-00111-3
40. Diamond WD, Loewy BZ (1991) Effects of Probabilistic Rewards on Recycling Attitudes and Behavior. J Appl Soc Psychol 21(19):1590–1607. https://doi.org/10.1111/j.1559-1816.1991.tb00489.x
41. Pravin Jeyaraj (2011) Incentives and the Culture of Recycling. Cultural Legitimacy and the International Law and Policy on Climate Change. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1926378
42. Ruiz B, Flotats X (2014) Citrus essential oils and their influence on the anaerobic digestion process: An overview. Waste Manage 34:2063–2079. https://doi.org/10.1016/j.wasman.2014.06.026
43. Papadopoulou E, Vaitsas K, Fallas I, Tsipas G, Chrissafis K, Bikiaris D, Kottaridi C and Vorgias K.E. (2018) Bio-economy in Greece: Current trends and the road ahead, The EuroBiotech Journal, Vol 2 Issue 3 | July 2018
44. Teigiserova DA, Tiruta-Barna L, Ahmadi A, Hamelin L, Thomsen M (2021) A step closer to circular bioeconomy for citrus peel waste: A review of yields and technologies for sustainable management of essential oils. J Environ Manage 280:111832. https://doi.org/10.1016/j.jenvman.2020.111832
45. Castrica M, Rebucci R, Giromini C, Tretola M, Cattaneo D, Baldi A (2019) Total phenolic content and antioxidant capacity of agri-food waste and by-products. Ital J Anim Sci 18(1):336–341. https://doi.org/10.1080/1828051X.2018.1529544
46. Shetty S, Mahin-Syed-Ismail P, Varghese S, Thomas-George B, Kandathil- Thajuraj P, Baby D, Haleem S, Sreedhar S, Devang-Divakar D (2016) Antimicrobial effects of Citrus sinensis peel extracts against dental caries bacteria: An in vitro study. J Clin Exp Dent. https://doi.org/10.4317/jced.52493

47. Zema DA, Calabrò PS, Folino A, Tamburino V, Zappia G, Zimbone SM (2018) Valorisation of citrus processing waste: A review. Waste Manage 80:252–273. https://doi.org/10.1016/j.wasman.2018.09.024
48. Xu W, Zhou C, Lan Y, Jin J, Cao A (2015) An incentive-based source separation model for sustainable municipal solid waste management in China. Waste Management & Research: The Journal for a Sustainable Circular Economy 33:469–476. https://doi.org/10.1177/0734242x15574979
49. Hong I, Park S, Lee B, Lee J, Jeong D, Park S (2014) IoT-based smart garbage system for efficient food waste management. Scientific World Journal 2014:1–13. https://doi.org/10.1155/2014/646953
50. Efozia N.F., Immanuel T., Odebunmi F., Giwa O., Balogun T., () Smart city: concept, applications and architectural model, Nigeria Computer Society, 12th International Conference, p.74
51. Mahato N, Sharma K, Sinha M, Cho MH (2018) Citrus waste derived nutra-/pharmaceuticals for health benefits: Current trends and future perspectives. Journal of Functional Foods 40:307–316. https://doi.org/10.1016/j.jff.2017.11.015
52. Galanakis CM, Aldawoud TMS, Rizou M, Rowan NJ, Ibrahim SA (2020) Food Ingredients and Active Compounds against the Coronavirus Disease (COVID-19) Pandemic: A Comprehensive Review. Foods 9:1701. https://doi.org/10.3390/foods9111701
53. Zuin VG, Ramin LZ (2018) Green and Sustainable Separation of Natural Products from Agro-Industrial Waste: Challenges, Potentialities, and Perspectives on Emerging Approaches. Top Curr Chem (Z) 376:3. https://doi.org/10.1007/s41061-017-0182-z
54. Contreras M del M, Castro E (2020) Extraction Strategies to Recover Bioactive Compounds, Incorporation into Food and Health Benefits: Current Works and Future Challenges. Foods 9:393https://doi.org/10.3390/foods904039
55. Gibovic D, Bikfalvi A (2021) Incentives for Plastic Recycling: How to Engage Citizens in Active Collection. Empirical Evidence from Spain Recycling 6(2):29. https://doi.org/10.3390/recycling6020029
56. Issa I, Delbrück S, Hamm U (2019) Bioeconomy from experts' perspectives – Results of a global expert survey. PLoS ONE 14:e0215917. https://doi.org/10.1371/journal.pone.0215917
57. Tripodo M (2004) Citrus waste recovery: a new environmentally friendly procedure to obtain animal feed. Biores Technol 91:111–115. https://doi.org/10.1016/s0960-8524(03)00183-4
58. Dilucia F, Lacivita V, Conte A, Del Nobile MA (2020) Sustainable Use of Fruit and Vegetable By-Products to Enhance Food Packaging Performance. Foods 9:857. https://doi.org/10.3390/foods9070857
59. Nanni A, Parisi M, Colonna M (2021) Wine By-Products as Raw Materials for the Production of Biopolymers and of Natural Reinforcing Fillers: A Critical Review. Polymers 13:381. https://doi.org/10.3390/polym13030381
60. Orjuela A, Clark J (2020) Green chemicals from used cooking oils: Trends, challenges, and opportunities. Current Opinion in Green and Sustainable Chemistry 26:100369. https://doi.org/10.1016/j.cogsc.2020.100369
61. Ismail H, Hanafiah MM (2020) A review of sustainable e-waste generation and management: Present and future perspectives. J Environ Manage 264:110495. https://doi.org/10.1016/j.jenvman.2020.110495