



UNIVERSITÀ
DEGLI STUDI
DI PALERMO

dSEAS

dipartimento
scienze economiche
aziendali e statistiche
department
of economics
business
and statistics

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Saving process within a zero waste strategy in Sicily: a system dynamics approach

Andrea Cuccia

Abstract Disposable society represents a way of living that is not sustainable anymore, mainly in a context like our planet where resources are really scarce. As theorized by Paul Connett, the guru of zero waste strategy, there is no waste until that material still contains a drop of usefulness. The core point of the paper is the implementation of a zero waste strategy in a small municipality in Sicily. By building up a SD model we can figure out how saving process connected to the decrease of amount of waste piled up in the landfill, has been boosting this virtuous cycle, which is bound to cope with the citizens claims about environmental care and lower tax burden level.

Keywords saving process · zero waste strategy · Dynamic Performance Management · System Dynamics · accountability

Riassunto

La sostenibilità può essere vista come la più importante sfida che l'umanità si appresta ad affrontare in questo millennio; infatti, guardando agli attuali livelli di consumo, sarebbero necessari almeno due pianeti se si assumesse a riferimento il modello di consumo europeo, quattro pianeti, invece, se si considerasse il modello di consumo americano. In questo contesto, "Rifiuti Zero" si configura come un obiettivo ad un tempo pragmatico e visionario in grado di spingere la collettività a rispettare la sostenibilità immanente nei cicli naturali e a valorizzare i materiali di scarto destinandoli ad ulteriori utilizzi. Il programma "Rifiuti Zero" è stato concepito da Paul Connett, professore di chimica presso la Santa Lawrence University, come alternativa all'incenerimento quale tradizionale metodo di trattamento dei rifiuti. In particolare, facendo

Phd student in "Model based public planning, policy design, and management",
University of Palermo E-mail: Missing

leva sulla responsabilità industriale e sul coinvolgimento attivo della collettività – previa sensibilizzazione della stessa grazie ad opportune campagne condotte dalle Amministrazioni Locali – il programma mira a ridurre alla fonte la produzione di rifiuti e ad estendere il più possibile il ciclo di vita dei prodotti grazie a pratiche di riciclo e di riuso. L'adozione di tale strategia, a partire dal 2012, da parte del Comune di Palazzo Adriano va interpretata come una scelta dettata da vincoli di bilancio sempre più stringenti e da obblighi normativi comunitari e nazionali sempre più incalzanti. Tale effetto combinato ha spinto il Comune a comprimere il più possibile i costi di smaltimento dei rifiuti attraverso la ricerca della conformità ad un obbligo comunitario-nazionale in merito alla frazione di raccolta differenziata da conseguire, nella prospettiva di soddisfare, al contempo, un interesse collettivo quale quello alla salubrità ambientale. La soglia del 65% come percentuale di rifiuti urbani differenziati raggiunta dal Comune di Palazzo Adriano nel 2015, era già stata formalizzata nell'art. 205 del D.Lgs. n. 152/06 come obiettivo da perseguire entro il 2012 e va oggi inquadrata in combinato disposto alla Direttiva Comunitaria n.98/2008 che ha fissato un nuovo obiettivo relativo alle pratiche di riciclo e riuso dei rifiuti urbani, espresso in termini di peso, da raggiungere entro il 2020. La Dynamic Performance Management (DPM) Chart, articolata in strategic resources, performance drivers ed end-results, diventa cornice ideale per la costruzione di un modello di system dynamics che si pone come integrazione ai tradizionali supporti informativi patrimoniali-finanziari nella valutazione dell'efficacia dell'azione pubblica. Il modello sviluppato illustra il funzionamento del sistema di smaltimento e le diverse possibili ramificazioni del ciclo di vita del prodotto "rifiuto" (la "waste management chain"), eleggendo l'area di raccolta ottimale (ARO) "Valle del Sosio" quale soggetto incaricato di gestire il servizio, sebbene quest'ultimo debba ancora entrare in funzionamento in sostituzione dell'ATO PA2, l'azienda pubblica responsabile del servizio fallita nel 2014. La DPM Chart si configura come plancia di comando volta a porre ad ordinamento le diverse variabili in gioco in termini di punti nodali di un reticolo di relazioni causali (causal loops); tale reticolo è destinato a rappresentare la performance dell'Amministrazione Pubblica, intesa sia come processo sia come risultati finali prodotti, enfatizzando, nel caso di specie, il ruolo critico assunto dalla pubblicizzazione da parte del Comune del risparmio conseguito – in ragione della riduzione di rifiuti conferiti in discarica – nel raggiungimento della sovrammensionata soglia del 65%. Tale opera di disclosure infatti, ha incentivato la popolazione sia a ridurre la produzione di rifiuti alla fonte sia a riciclare quanto più possibile la frazione di rifiuti ineliminabile immessa nel sistema, assicurando così la persistenza nel tempo di un circolo virtuoso e dando sostanza al paradigma dell'accountability teorizzato da Behn. Infine, l'avvento dell'ARO, come realtà consortile che coinvolge i Comuni dell'area "Valle del Sosio", unitamente al sistema di consorzi (quali COREPLA e COREVE) preposti alla lavorazione dei diversi materiali di imballaggio, potrebbe sancire l'inossidabile saldatura fra le due leve del programma "rifiuti zero", la responsabilità industriale e il coinvolgimento della collettività. Se da un lato, infatti, le lavorazioni effettuate dai singoli consorzi diventano pre-requisito indefettibile per riconsentire uno sfruttamento industriale dei materiali di imballaggio; dall'altro lato, le compensazioni – alimentate dai contributi CONAI versati da produttori e utilizzatori per gli

ulteriori imballaggi immessi nel mercato – per i maggiori costi legati alla raccolta differenziata, conferite dal sistema di consorzi all'ARO e poi traslate sui singoli Comuni in termini di minori tasse per i cittadini, finirebbero per alimentare ulteriormente la persistenza nel tempo di tale schema virtuoso.

Parole chiave *risparmio, strategia rifiuti zero*

1 Introduction

Sustainability might be seen as the most important challenge mankind is going to face in this millennium; in fact, given the ongoing consumption rate, we ought to live at least in two planets assuming the European consumption model, whereas if we assumed the American one, we would need at least 4 planets¹. By comparing with this backdrop, « *Zero Waste is a goal that is both pragmatic and visionary, to guide people to emulate sustainable natural cycles, where all discarded materials are resources for others to use*² ». Zero Waste program might be seen as a philosophy, a strategy, and a set of practical tools seeking to eliminate waste, not to manage it. It was conceived for the first time by Paul Connett, professor of chemistry at the Saint Lawrence University, who has been very renowned throughout the world since he has stood against incineration as the widely-accepted treatment method of waste by proposing at the opposite a different way of planning resources life cycles so that all the products are intended to be reused (cradle to cradle scheme, instead of the overwhelming linear cradle to grave scheme).

By following this perspective, it has been obtained the main purpose of zero waste strategy: not to figure out more sophisticated methods to destroy waste, vice versa, to encourage production of products and packaging materials that will never be destroyed³.

The change in the paradigm this strategy is trying to foster, is essentially summed up in the 3-R scheme: reduction at the source and recycling and reuse, just to extend the life cycle of products.

More deeply, this program is conventionally made up of 10 steps:

1s Source separation, made by citizens on their own just to let the intrinsic value of each product persist and not to make them contaminated by the blend with other different items;

2d Door to door collection, made by employers paid by the municipality;

3 Composting, arising from the organic waste fraction and intended to be use as natural fertilizer for the soil;

4 Recycling;

¹ To get further information, read J. Moore and W. E. Rees, "Getting to One-Planet Living", chapter 4 in "State of the World: is sustainability still possible?", The WorldWatch Institute, Island Press, 1 edition, 15th april 2013, p.41.

² The whole definition is available on the official website www.zerowasteurope.eu/about/principles-zw-europe/[2017].

³ P. Connett, "*Rifiuti zero, una rivoluzione in corso*", Dissensi Editor, 2012, p.11.

5 Ruse, Repair& Community Center;

6 Waste reduction initiatives, for example forbidding the selling in the supermarket of disposable plastic dishes;

7 Economic incentives, to make people aware that making waste the least possible is first of all useful to keep the cost of waste management service down;

8 Residual separation & research center, that is supposed to act on what has been impossible to retrieve in the earlier steps;

9 better industrial design (namely industrial responsibility);

10 Temporary landfill, given that disposal infrastructure such as landfills or incinerators should no longer be built and be progressively phased out as prevention & recycling rates increase⁴.

Surely the visionary aim of Zero Waste within 2020, requires two pillars to be pursued:

- **Engaging community**, since it becomes crucial to undertake public campaign just to make people receptive to this kind of subject and to invite them to adopt waste free practices;

- **Industrial responsibility**, as just a guarantee of designing long-lasting, easily maintainable and repairable products, of reducing packaging and redesigning those products that cannot be safely reused, recycled and composted. Lastly, industrial responsibility consists also of reusing parts and material coming from discarded products and material in line with a circular economy where every “waste” output of one process becomes an input for another such that the utility of the material is maximized. In this sense it might be seen as a further R to add to the traditional 3-R scheme, that boosts both recycle and reuse rate by improving the traditional design of products⁵.

Adopting such a policy for a small municipality like Palazzo Adriano⁶, that is made up of less than three thousands of inhabitants, might be seen as a wise choice tackling the issue of intergenerational equity.

Recently municipalities in Italy have been involved in the grip of the fiscal compact, in line with European diktats and the tough economic and financial situation. As a consequence, they have been approaching the need of a spending review aimed at squeezing the management costs as much as possible. Fiscal compact, as fiscal chapter of the Treaty on Stability, Coordination and Governance in the Economic and Monetary Union, signed on 2 march 2012 formalized the need for governments to keep as sustainable their public finances and to prevent a general government deficit just to safeguard the stability of the euro area as a whole; accordingly, it also requires the introduction of specific rules, including a "balanced budget rule" and an automatic mechanism to take corrective action. This rule has been cascaded on municipalities forcing them to hold down expenditures level just to stabilize their financial equilibrium.

⁴ P. Connett, “*The Zero Waste Solution: untrashing the Planet One Community at a Time*”, Joni Praded Editor, 2013, p.15 and following pages.

⁵ J.M. Simon, “*Stirring paper*”; Second Conference on Economic Degrowth for Ecological Sustainability and Social Equity March 26-29th 2010, Barcelona, pp. 1-2

⁶ Palazzo Adriano is a little town in Sicani Mounts, western Sicily, belonging to the Metropolitan Area of Palermo

Obviously transfer of waste in landfill implies an incurring cost, referred to the incineration system as last treatment stop for the waste piled up in the landfill. In the last years, in accordance with the fiscal compact and with a view of achieving scale economies, it has been spread the idea of conferring waste management system to public consortia of services called ARO (Optimal Collection Area), whose costs will be splitted up among the different participating municipalities. Specifically, the municipality of Palazzo Adriano will be merged with the municipalities of Bisacquino, Prizzi, Chiusa Sclafani and Giuliana, in the “ARO-Valle del Sosio”, assuming that «*they generally represent a rural and mountainous area with a low population density*⁷». This consortium has been introduced by Regional Law n. 3/2013 but it has not begun to operate yet because of some bureaucratic quibbles about absorbing the employers referred to ATO PA 2, former public company owned by municipalities and responsible for waste collection, that has been failed in 2014. Therefore waste management will be outsourced in favor of a public consortium that will take care of workforce management, devices and facilities, maintenance investments and processing waste in landfill. In the meanwhile, from 2014 waste management has been assigned to a private company that made a tender for managing this service and it won.

Obviously, respect to the private one, Public sector performance has a broader impact on the quality of life of people and may constitute either an acceleration factor or a constraint for the growth of the local area⁸.

In this sense, the decision about which waste management system municipality is prone to adopt is a clear demonstration of what it has been already said. Reducing the amount of waste in landfill by implementing a zero waste strategy, as well as an economic benefit (given the saving connected to the refusal of the incineration system as the main waste treatment system) also turns into a driver simultaneously of direct and indirect benefits for society: on the one hand it satisfies the collective interest in the environmental care; on the other hand it creates the conditions to generate redundant positive externalities that are bound to strengthen the image and attractiveness of the reference area.

⁷ Studio di progettazione e consulenza aziendale Dott. V. Marinello, “*Progetto Area di Raccolta Ottimale (ARO): comuni di Palazzo Adriano, Prizzi, Bisacquino, Giuliana, Chiusa Sclafani*”, 2014, p.1.

⁸ The greater impact is proven by the broader array of products Public Sector is used to provide to the citizenry respect to the private one. Specifically, Public Administration is conventionally used to provide these products: [F0B7?] Laws and administrative deeds;

- Collective goods;
- Individual goods of collective interest;
- contributions;
- Rules, programs, guidelines.

E. Borgonovi, “*Principi e sistemi aziendali per le amministrazioni pubbliche*”, Egea, 2005, p.62.

2 AIM OF THE PAPER

Recycling has always been a challenge for municipalities. In particular, reviewing the results attained throughout Italy, it is known that the main causes of the failure of such initiatives are:

- inability of municipality to raise awareness of the population, if the municipality either has not achieved satisfying fraction of waste recycled level or it has not been able to be accountable to the citizens for the results of such a policy⁹;
- lack of sufficiently strong control mechanisms, ready to ensure the continuation of a similar program, which of course, at least in the short term, encounters strong resistance, given that it threatens a more convenient but also more polluting model of life.

Obviously, little municipalities are more likely to get a target fraction of waste recycled sooner respect to the greater ones. In particular, according to Ispra¹⁰ recycling rate of over 60% is more likely in municipalities including both between 2,501 and 5,000 inhabitants and between 5001 and the 15,000 inhabitants (respectively 52,6% and 55,9% of the corresponding class of municipalities have reached the target fraction). Over 60% of recycling has been achieved also in the 33,3% of municipalities comprising between 100,001 and 200,000 inhabitants. Instead, there's no municipality with a population of more than 200,000 inhabitants that has been reaching such a threshold¹¹.

However, it is useful to take into account the troubling datum about level of fraction of waste recycled in Sicily: in 2014¹² one third of all the municipalities did not go beyond the 5% and in 2015 the regional recycling rate has not recorded so many improvements, given a passage from 12,5% of 2014 to 12,8%¹³.

⁹ «How will who hold whom accountable for producing whose results? The question of democratic accountability for performance is really four distinct but interrelated questions: who will decide what results are to be produced? Who is accounting for producing these results? Who is responsible for implementing the accountability process? How will that accountability process work? [...] Thus accountability for performance requires some explicit expectations about what results will be produced by when». R. D Behn, "Rethinking Democratic Accountability", 2004, Brookings Institution Press, Washington DC, pp. 62-63.

¹⁰ Public Agency supervised by Ministry of the Environment, responsible for technical scientific activities connected to environmental care, protection of water and soil conservation.

¹¹ Ispra, "Rapporto rifiuti urbani", Ed. 2016, pp. 64-65. Available on: <http://www.isprambiente.gov.it>[2017].

¹² For more information: <http://meridionews.it/articolo/44305/differenziata-i-risultati-dei-390-comuni-siciliani-unterzo-sotto-il-5-regione-impone-prescrizioni>[2017].

¹³ Surely there is a remarkable delay about aggregation of data referred to the separated waste collection level achieved in each municipality. Governor of Sicily, has recently declared that in 2016 Sicily has reached 21 % of fraction of waste recycled. In particular, he stated it has been observed locally an increase of 1% on average respect to the year before. Actually, to increase this datum massively, it is necessary to focus on the big cities, where fraction recycled is still low (around 10% in 2015, according to Ispra). To read more, Ispra, *op.cit.*, p. 63 and following pages and http://palermo.repubblica.it/politica/2017/01/27/news/rifiuti_crocetta_annuncia_differenziata_al_21_per_cento_ottimo_risultato_-156996772 [2017].

Recalling the success of the San Francisco waste system¹⁴ as successful pioneer of this new treatment method of waste, the aim of this research is to explain how the benefits for the citizens have sprung up from the start of this program (with its ten steps) since 2012 in Palazzo Adriano, a small village just 80 km far from Palermo. To do that, it has been crucial to integrate the 3-R scheme with the S of saving money, just to highlight what has been strengthening this strategy over time, bringing out a virtuous waste management system, embedded into a tough regional situation.

Time horizon coincides with the lag of time whose data have been provided by municipality, namely a period of five years, including the year before the implementation of this strategy. This choice is justified by desire of understanding the strength of that change implementation of the policy has been unleashing over time.

To summarize, this paper is intended to answer the following research questions:

- a) How does the ensuing waste management system work?
- b) Why saving process might be seen as a significant push towards zero waste goal, influencing Behn's accountability paradigm?
- c) Which are the most conducive causal loops to explain behavior of waste cumulated in landfill?

3 METHODOLOGY

Assuming that unpredictability and dynamic complexity are the main enemies for our better understanding of a system – in the classical meaning developed by Von Bertalanffy as a complex of tightly intertwined elements – and given that all is change, policy-maker ought to oversee changes occurring within a certain system at many time scales, and trying to keep track of interactions among these different scales¹⁵. A system without a time-oriented perspective is not a system. Therefore, if a municipality wants to succeed in managing a system, it should cater for performance, defined both as outputs (and mainly outcomes, as projections of the outputs in the outer local system in the long run) it is supposed to get at the end of its policy, and the process that is in charge for those end-results¹⁶.

¹⁴ Currently, San Francisco diverts 80% of its waste away from landfills. According to New York *Times* reporter Matt Richtel, «*San Francisco also has a world-class reputation for its composting processes, which turns food waste into fine, coffee-like grounds that is sent to farms as fertilizer*». And he observed that San Francisco has been becoming the “Silicon Valley of recycling”. Reference: http://www.nytimes.com/2016/03/29/science/san-francisco-the-siliconvalley-of-recycling.html?_r=0[2017]. To still lift this threshold up to 100% in line with the ambitious Zero Waste Strategy goal within 2020, herewith listed a practical guideline for citizenry on: <http://sfenvironment.org/zero-waste>[2017].

¹⁵ J.D. Sterman, “*System thinking and Modeling for a complex World*”, McGraw-Hill, 2000, p.22.

¹⁶ Nowadays citizens are demanding better results from government at a time when resource constraints are increasing, and level of trust in government at all levels is at an historic low. So to get more accountability rejecting black box concept and making all the process transparent as much as possible has become a priority. M.B.Sanger, “*Does measuring performance lead to better performance?*”, *Journal of Policy Analysis and Management*, 1-18, 2012, p. 1.

Combining SD models with “information feedback support” models based on financial perspective and static performance management, should be a profitable trick to foster mental models’ elicitation and improve organizational capabilities in assessing performance through a sustainable development perspective (dynamic performance management)¹⁷.

Precisely, Dynamic Performance Management systems do not only intend to carry out a quantification of effects arising from the implementation of specific public policies, but also have the benefit of providing appropriate information to decision makers who can use them to influence in a targeted manner the reference environments and to evaluate the results achieved¹⁸. In fact, SD modeling techniques, embedded in a DPM perspective, allow to implement a double loop learning process since on the one hand the modeling process is rooted on the elicitation of decision makers’ perceptions of the real world; on the other hand, decision makers’ mental models are challenged through model validation (namely, the search for a consistency between the model hypothesis on the system structure and the simulated behavior). Validation of a SD model might be seen as an input that enables policy maker to deploy an action that can rely on a basement with an acceptable level of scientific rigor¹⁹. Furthermore, SD modeling challenges mental models through simulation and it should also be considered as a practical way to test in a “protected” environment the consistency – in terms of robust trade-offs perception – of their own decisions²⁰.

In order to provide decision-makers with proper lenses to interpret such phenomena like unpredictability and dynamic complexity, to understand feedback structure underlying performance, and to identify alternative strategies to change of the structure for performance improvement, SD modeling has been used to support an understanding of:

- how end-results can be affected by performance drivers;
- how performance drivers can, in turn, be affected by the use of policy levers aimed to influence strategic resource accumulation and depletion processes;
- how the flows of strategic resources are affected by end-results²¹.

¹⁷ C. Bianchi, “*Dynamic Performance Management*”, Springer International Publishing, 2016, p. 37.

¹⁸ C. Bianchi, W.C. Rivenbark, “*Alla ricerca dei fattori rilevanti nell’adozione dei sistemi di gestione della performance nelle amministrazioni pubbliche territoriali. L’analisi di due casi di studio*”, Azienda Pubblica, n. 1, 2013, p. 36.

¹⁹ System dynamics might push away the performance paradox risk. This phenomenon is caused by the tendency of performance indicators (especially when they are conceived as static) to run down over time. They lose their value as measurements of performance and can no longer discriminate between good and bad performers. A typical process that can present this risk is positive learning, according to which, as performance improves, indicators lose their sensitivity in detecting bad performance. M. W. Meyer & V. Gupta, “*The performance paradox. Research in Organizational Behavior*”,

²⁰ «*Microworlds (otherwise stated as: “interactive learning environments”, or “management flight simulators”) are SDbased simulation models aiming to foster policy debate. The use of such simulators, supported by a learning facilitator, can help policy makers understand the dynamic relationships between strategic resources and performance variables*». To read more, C. Bianchi, “*Dynamic Performance Management*”, *op. cit.*, p. 199.

²¹ C. Bianchi, *op. cit.*, p. 72.

After all, Zero Waste strategy is a shift of paradigm that has required time to be understood and accepted by citizens, and initiatives which take up time and can thrive over time in a certain way, depending on how the action started out from the beginning (path dependence²² as a peculiar feature of SD) typically represent the natural area of SD approach²³ applicability.

System Dynamics gives the possibility to build up an exploratory model looking into the dormant dynamics that would justify the adoption of such a policy and reasoning in terms of stocks (states) and flows (changes) in accordance with the principle of accumulation²⁴.

Assuming that stocks have four important characteristics (they have memory; they change the time shape of flows; they decouple flows; they create delays²⁵), stock and flows structure might be seen as a completion of another pillar of SD approach, the causal loops diagramming, namely the possibility of mapping the system in terms of cause and effect relationships between individual system variables; the latter ones²⁶, when linked, form closed loops that feed back to the structure altering the relative importance of each of the variables listed in the system²⁷.

By taking resort of system dynamics it becomes possible to explicit the patterns of casual loops hidden in a traditional statistical tool²⁸, trying to distinguish, in the present case, the commitment both at source and at the end of the life cycle time of each product to reduce the stock of waste in landfill.

²² «*Taking one road often precludes taking others and determines where you end up*». J.D. Sterman, *op.cit.*, p.22

²³ This methodology has been conceived by J. Forrester since 1950s at MIT.

²⁴ L. Booth Sweeney and J.D. Sterman, «*Bathtub dynamics: initial results of a systems thinking inventory*», System Dynamics Review, volume 16(4), 2000, pp. 252-253.

²⁵ D.M. Buede & W.D. Miller, «*The engineering design of systems: models and methods*», Wiley, 3rd Edition, 2016, p. 464.

²⁶ There is a need of a framework to frame any attempt of modeling management control system. To cope with this necessity, a good starting point is surely sorting out a useful conceptual framework:

- to define an appropriate set of independent variables related to the firm and, variables that explains environment and its actual influence over the control process;

- to select features of managing control system;

- to find out the links between any facets of the process listed above.

F. Amigoni, «*Planning management control systems*», 1978, Journal of Business Finance and Accounting, 5(3), 279-291, p. 1.

²⁷ «*Learning from performance measures, however, is tricky. It isn't obvious what lessons public managers should draw about which factors are contributing to the good or poor performance, let alone how they might modify such factors to foster improvements. Improvement requires attention to the feedback*» R.D. Behn, «*Why Measure Performance? Different Purposes Require Different Measures*», Public Administration Review, 63(5), 2003, p.8.

²⁸ For example a multiple regression analysis whose aim would have been trying to explain how the criterion variable (in this case, the tons of waste permanently conferred to the landfill) is affected by the predictor variables, and to what extent its change over time is due to the influence of each predictor variable, individually considered. Therefore, recalling the 3R scheme integrated with C (composting) the author would have built up a multiple regression model drawing on some proxy variables representing the pillars of a common zero waste strategy.

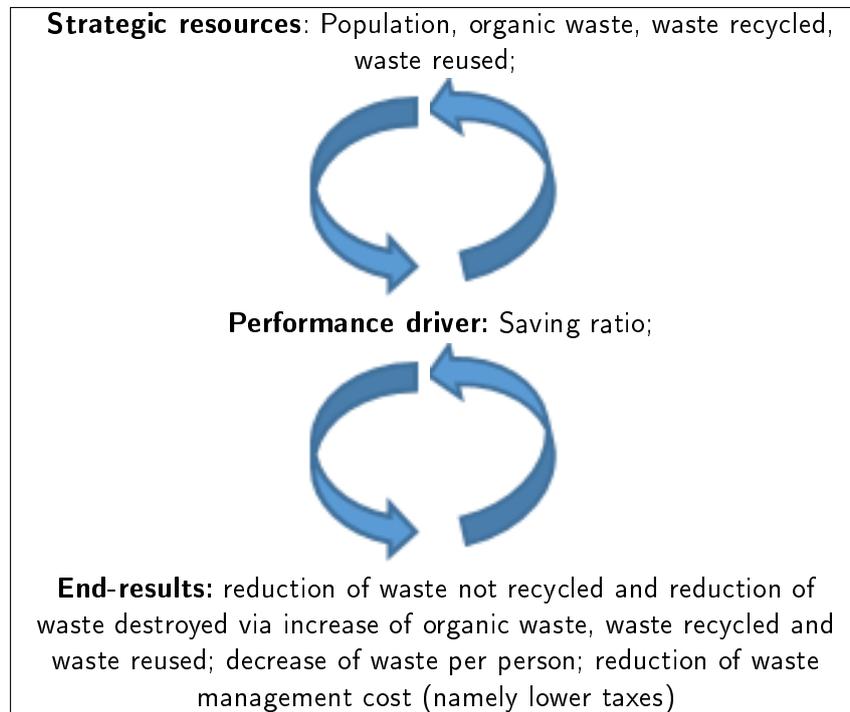


Table 1 Dynamic Performance Management Chart applied to a zero waste strategy

Therefore, a Dynamic Performance Management Chart based on SD modelling techniques is a useful dashboard to keep track of performance, both as process and end-results.

DPM chart, as structured below, acknowledging first the strategic role of population as the main factor that affects waste collection, emphasizes the importance of saving process, shown as a ratio between the actual waste management cost level and a target. This ratio might be seen as a performance driver that leads operationally, as end-results, to a reduction of waste not recycled and finally to a reduction of waste destroyed; this happens thanks to the concurrent increase of organic waste, waste recycled and waste reused that flow into the corresponding stocks, feeding strategic resources ready to be exploited or marketed. But saving process is also intended to decrease the amount of waste made by each person, diminishing as a consequence the total amount of waste produced each year. From an economic point of view, these end-results determine lower taxes motivating citizens to fuel this pattern persistently.

4 Results of the empirical survey

Reason that pushed the municipality of Palazzo Adriano to increase the fraction of recycled waste, with all kinds of benefits (economic, environmental and externalities) identified before, lies in the alarming datum of the amount of waste piled up in the landfill for the year 2011, namely 693,84 tons.

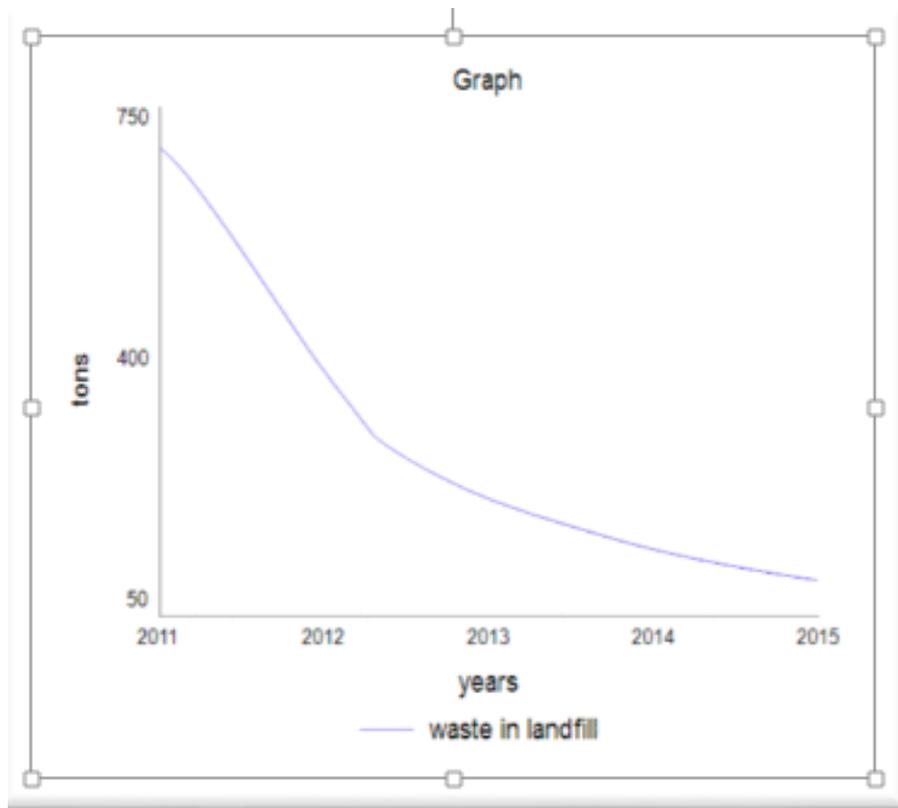


Fig. 1 Tons of waste piled up in landfill during the period 2011-2015

To reverse this dangerous trend, the mayor of Palazzo Adriano, once elected, decided to adopt in 2012 a zero waste strategy; specifically, he pledged to reach at the end of the mandate the ambitious threshold of 65% of recycled waste²⁹, which represents tons of waste diverted away from landfill and incineration system as last treatment stop.

As a consequence, municipality has achieved the following decreasing pattern of behavior related to the amount of waste irreversibly conferred to landfill, getting to the level of 99 tons in 2015:

At the same time it has been seen during the period 2011-2015 an increasing pattern of behavior of the fraction of waste recycled, up to the threshold of 65% that municipality set as target at the beginning.

²⁹ Directive n. 98/2008 has established that by 2020, preparing for re-use and recycling of waste such as at least paper, metal, plastic and glass from households and possibly from other origins as far as these waste streams are similar to household ones, shall be increased to at least 50% in terms of weight. Truly, threshold of 65 % had been already listed in the Italian judicial system in art. 205 Legislative Decree n. 152/06, as an objective to be pursued by 2012. To read more, go to AA VV, “*Libro verde per la sostenibilità ambientale delle infrastrutture nodali di trasporto*”, Franco Angeli, 2016.

Fraction of waste recycled	
2011	4%
2012	24%
2013	62,77%
2014	63%
2015	65%

Table 2 source: Municipality of Palazzo Adriano

year	population
2011	2227
2012	2200
2013	2178
2014	2155
2015	2135

Table 3 Source: Istat

Even though depletion of towns due to the juvenile migrations abroad or in the north looking for a job a common issue spreading in the South of Italy and particularly in Sicily³⁰ it would be biased to ascribe to the demographical issue such a progression of waste piled up in the landfill, since the demographical situation in Palazzo Adriano has been shaped in the last five years in the following way:

By comparing the significance of data related to the decrease of waste in landfill with the decrease of population over time, it is easy to realize that surely there have been other aspects that might be considered as more significant to clarify the pattern of behavior observed during the period of simulation.

To realize which causal loops are the most conducive to explain the dynamics underlying the implementation of such a policy, it is useful to take resort of the whole waste chain built up in the SD model³¹. Its development has been grounded in the idea of splitting up this chain in different steps just to figure out the destination of the waste produced each year.

There are two key conveyor stocks in this chain: waste produced that represents the amount of waste produced that is going to be subdivided, in accordance with its destination in three different outflows (organic waste, waste recycled, waste not recycled); the other one, waste in

³⁰ «The highest long-term unemployment ratios were principally concentrated in southern and peripheral regions of the EU. There were 11 Greek regions, seven Italian regions (including the island of Sicilia), four French départements et territoires d'outre-mer (no data available for Mayotte), three regions from each of Bulgaria, Portugal (including the islands of Madeira and the Açores) and Slovakia, the two autonomous Spanish cities, both of the Croatian regions, and the Belgian capital city Région de Bruxelles Capitale/Brussels Hoofdstedelijk Gewest». Eurostat, “Eurostat Regional Yearbook”, 2016, p.112.

³¹ The variable “Equilibrium Switch” warns that the model has been initialized in equilibrium.

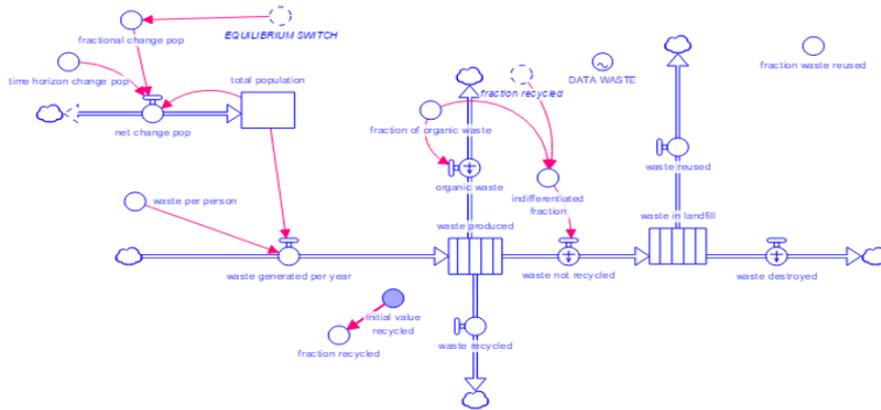


Fig. 2 The waste management chain

landfill expands upon one of the three possible destination, and in turn is going to be depleted by two outflows, namely waste destroyed and

waste reused which represent respectively the ultimate passage or a soft brake respect to the default scheme.

The conveyor stock waste in landfill accumulates the inflow waste not recycled, which comprises the amount of waste collected that has not been undergone by zero waste strategy. For this reason the leakage fraction referred to waste not recycled, that flows out of the previous conveyor stock (waste produced) has been determined as completion of the sum of fraction recycled and fraction of organic waste, namely the leakage fractions respectively referred to the outflow waste recycled and organic waste (compost).

Waste not recycled passed through – in accordance with a First in First out scheme as a typical feature of the conveyor scheme³² – the stock to fuel the outflow waste destroyed, namely the amount of waste bound to be sent to the incinerator. Leakage fraction referred to waste destroyed has been set as exponential just to sketch a nonlinear discharge. Transit time related to the conveyor stock waste in landfill embodies somehow the constrain of capacity, since it takes time to treat waste not recycled and to destroy definitely what it has been not possible to recycle before.

Waste in landfill has been depleted also by another outflow that takes into account one of the three pillars of the zero waste strategy, namely reuse. Reused waste comprises all that stuff like aluminium or steel that was not possible to recycle in the steps before. In this case the inflow waste reused has been defined by selecting as leakage fraction of waste destroyed the completion of fraction waste reused. Therefore, waste reused has been represented by everything

³² «The conveyor allows for a first in, first out (FIFO) behavior, with allowance for leakage and for probabilistic delay times», T.K. BenDor & S.S. Metcalf, “Conceptual Modeling and Dynamic Simulation of Brownfield Redevelopment”, 2005, p.11. Available on: <http://www.systemdynamics.org/conferences/2005/proceed/papers/BEND0191.pdf> [2017].

else is not going to flow out of the stock as waste destroyed. Positive correlation between the amount of waste in landfill and the amount of waste reused might be seen as a proof of the schedule referred to the treatment needed to make those products ready to be used again. In fact, what it has been impossible to recover in the steps before, it is going to be transferred to a provisional landfill just to undergo some interventions in order to refresh its usefulness.

On the other side of the waste chain, waste produced is boosted by an inflow that witnesses the role of population as the main responsible for waste production. Broadening the scope, waste produced is a conveyor stock that has been depleted by three outflow. One is referred to the compost production loop; another one is referred to the recycling loop, while the last one is related to the transportation to the landfill.

About compost, renowned as common natural fertilizer used locally for farms, it is useful to know that the corresponding outflow organic waste turns out to be related to the leakage fraction “fraction of organic waste” that has been kept constant (2,3% of total waste produced) during the period as well as the fraction of waste reused (3,6% of the amount of waste in landfill), because by looking at the data gleaned from municipality it has been seen a quasi-constant pattern of behavior. About reuse and recycled waste (which in turn comprises fractions of glass, paper and cartoon diverted from the transportation to the landfill) joining CONAI system³³³⁴, producers and users are obliged to pay a contribution depending on the type of packaging waste brought out in the market (paper, plastic, cartoon, aluminium, steel or glass). CONAI withdraws a minimum fraction of this contribution for the fulfillment of its bureaucratic tasks, while the greater part of it is bound to be sent to the Consortia responsible for processing each type of packaging waste in order to refresh their usefulness³⁵.

These consortia, in turn, according to the ANCI³⁶-CONAI framework agreement (Accordo quadro ANCI-CONAI), assign to municipalities a compensation to cover higher costs connected to the differentiated collection of waste.

Currently, municipality are used to outsource waste management to private companies, but in the future, Palazzo Adriano together with the other municipalities, as said before, will manage this service by empowering a consortium of public services.

For this reason, model has been completed by internalizing the ARO system that will start out soon, replacing the entrustment to the private company.

In the past, as a guarantee for the success of recycling programs developed by each municipality, it has been decided to set up a recovery center (Centro Comunale di Recupero) for recycled waste in Bisacquino, chosen because it is equidistant for all those municipalities join-

³³ No profit management system for packaging waste in Italy introduced by Law Ronchi (Legislative Decree n. 22/97).

³⁴ For more information, go to <http://www.conai.org/chi-siamo/cose-conai>. CONAI is a member of EXPRA, the alliance for the extended producer responsibility, the European organization that represents the no profit management system for packaging waste [2017].

³⁵ For example COREPLA is the consortium delegated for processing plastic, while COREVE is that one responsible for processing glass.

³⁶ The category association including all the municipalities in Italy.

ing “Valle del Sosio” area. This center dealt with temporary storage of recycled waste, awaiting to be sent to each consortium designated for processing each type of packaging (COREPLA, COREVE).

As said before, from 2014, given the failure of the ATO PA2, waste disposal service has been outsourced in favor of a private company, Traina srl. Assuming that this private company is equipped with a transference station in Cammarata (a municipality around 40 km far from Palazzo Adriano), currently recycled waste is stored there, until quantities piled up in the ecological island – which is located in each of the municipalities of the reference area – become commercially interesting; whereas undifferentiated waste is ordinarily sent to a landfill specifically identified by the Regional Government (currently Bellolampo, the main landfill of Palermo, whereas in the past it was Siculiana). Obviously, with the emersion of ARO system, as shown in the above mentioned “Progetto ARO”, it is expected to reactivate the center of Bisacquino.

Therefore, to sum up, recycled waste is first:

- conferred to the ecological island, located in each municipality joining ARO-Valle del Sosio;
- then transferred to the transference station of the Traina company, when ecological island has accumulated such quantities to motivate transport (obviously, transporting small quantities would be uneconomic); however, whenever load exceeds 20 cubic meters, it is required a permission from the Province Government³⁷.

Getting back to the end of the waste chain, amount of waste destroyed is bound to determine a total cost due to the treatment of waste in landfill required. This cost is equal to the tons of waste destroyed per year multiplied by the cost per ton treated. Precisely, it has been set equal to 102 euro per ton conferred, using an average value since cost per ton treated has been kept quasi stable over time. Consequently, the more waste municipality has carried to the landfill awaiting to be destroyed, the more cost it needs to bear. This cost determines participation cost ARO, together with devices and maintenance investments and workforce cost, given that there are some employers appointed for the waste collection referred to Consortium “ARO -Valle del Sosio”³⁸. Also, zero waste strategy starting investment represents a sort of sunk cost that Municipality bore at the beginning just to let zero waste strategy program start out. Therefore, it is a sort of umbrella term that comprises all the investments referred to disclosure in favor of the citizenry and building or purchase of the facilities connected to the treatment of waste in accordance with this new regime or devices referred to this program (for example the baskets related to each type of waste just to allow people to differentiate the waste produced at the beginning of our whole waste chain). As a consequence, the whole waste management cost for

³⁷ Art. 183, letter m, Legislative Decree n. 152/2006. Available on: [http://www.camera.it/parlam/leggi/deleghe\[2017\]](http://www.camera.it/parlam/leggi/deleghe[2017]).

³⁸ As said before, hypothetically, they will be the same ones referred to the ATO PA2, the former public company responsible for the waste management system until 2014

municipality is equal to the cost of investments bore at the beginning just to make the program start out plus the participation cost ARO.

Every year municipality has gathered a saving due to the lower level of waste piled up in the landfill thanks to the implementation of this program, which is intended to hold the waste management cost down more and more. This value has been compared with the initial waste in landfill cost referred to 2011, namely the year before the start of the program. The underlying idea is that the less waste municipality is used to confer to the landfill the more saving respect to the year 2011 it is bound to get year by year and at the end the lower taxes citizenry is supposed to pay as a reflection of expenditures downsizing.

By comparing the saving achieved thanks to the implementation of a zero waste strategy with a target waste management system cost to be pursued during the mandate and defined as 25% less than the waste management cost referred to 2011 (almost 400,000 euro), it is possible to build up a ratio that symbolizes the attempt to get to the target as much as possible. *Sic stantibus rebus*, according to financial statements referred to 2015, waste management cost has diminished to 322,100 euro³⁹. Obviously once this virtuous cycle has started out, the more it lasts, the more difficult it will be to get a further improvement, both in terms of saving and increase of the fraction of waste recycled⁴⁰.

Saving ratio, in terms of policy, internalizes efforts of municipality to make citizens more and more aware of benefits emerging from such ongoing virtuous cycle, by periodically exposing – personally encountering citizens or resorting to social network – an in-depth analysis of the state of art. By way of example, two meetings have been mentioned: the meeting "zero"⁴¹, where municipality for the first time explained the program, with its ten steps, to citizens on 10 July 2012; the other one relating to the visit in Palazzo Adriano on September 26, 2012 of Paul Connett, the guru of zero waste strategy⁴².

The above-mentioned ratio becomes the input of a graph function that embodies the idea that the more saving municipality gets the more citizens are inclined to recycle, looking at the benefits they might get thanks to recycling. This graph function, that is bound to spring up from 2012 in accordance with the beginning of the program, is going to influence the fraction recycled, since it is bound to be added to the initial value of fraction of waste recycled (referred to 2011), enhancing or diminishing it.

Herewith represented the pattern of behavior assumed by the graph function during the simulation period:

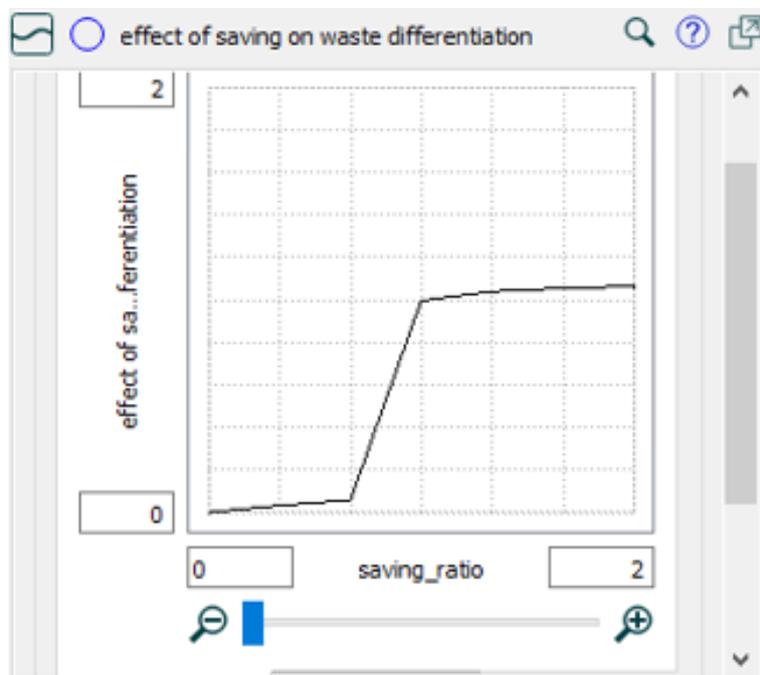
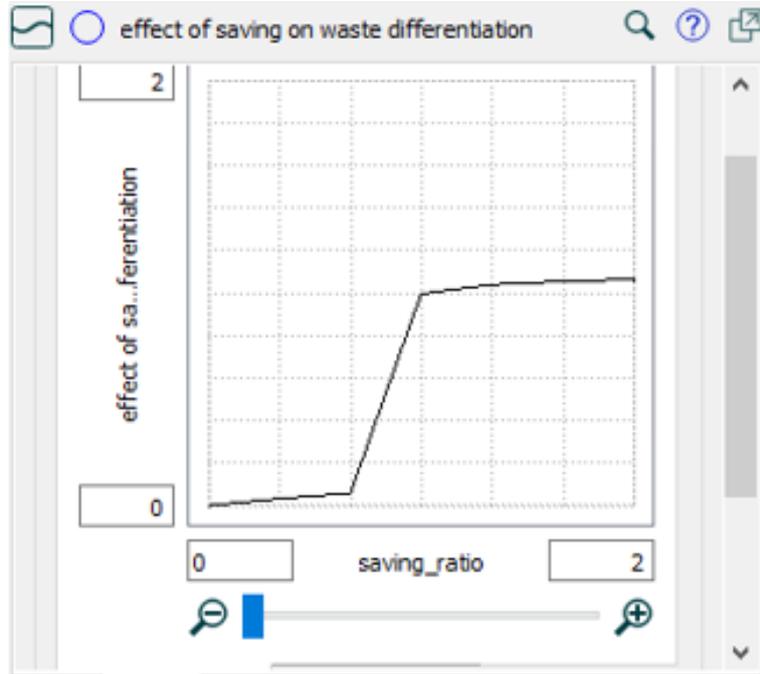
Introducing the above mentioned graph function gives the possibility to show the first major causal loop (recycling loop) that may explain why there has been a decreasing pattern of behavior for the amount of waste discharged in the landfill.

³⁹ <http://www.comune.palazzo Adriano.pa.it/it/DelibereConsiglio/2016/Luglio/CONTO%20DEL%20BILANCIO%202015%20-%20PARTE%20II%20SPESA.pdf> [2017].

⁴⁰ This reasoning has been embodied in the decreasing decreasingly pattern of behavior referred to the amount of waste in landfill.

⁴¹ <http://www.magaze.it/wps/2012/07/04/parte-il-16-luglio-la-campagna-per-la-raccolta-differenziata-a->

⁴² <http://www.magaze.it/wps/2012/09/26/palazzo-adriano-con-paul-connett-verso-rifiuti-zero-una-rivoluz>



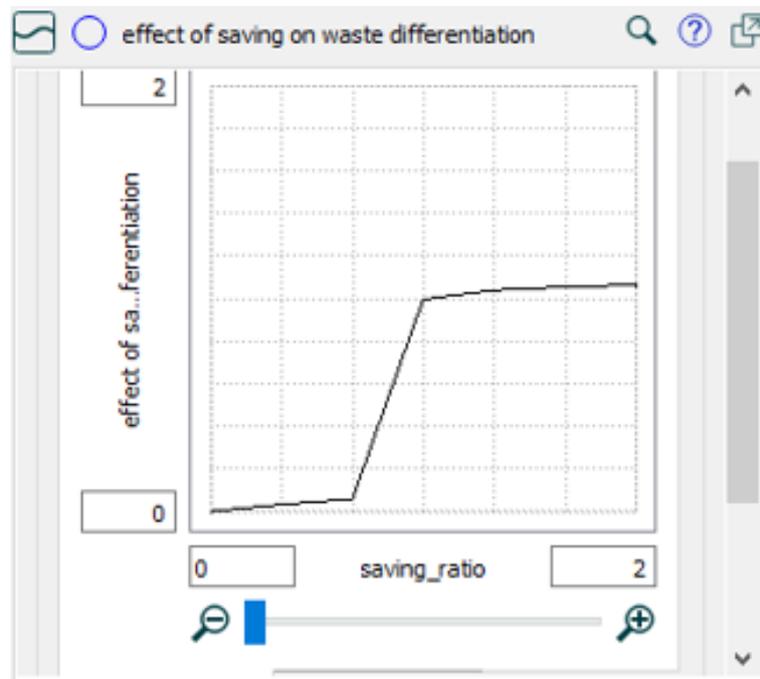


Fig. 3 Graph function “Effect of saving ratio on waste differentiation”

Recycling loop is a reinforcing loop which refers to the recovery of usefulness of the amount of waste that it has been already circulated.

Implementing such a program activates a key factor of a typical zero waste strategy, namely recycling, causing waste in landfill and waste destroyed to decrease; this means lower cost for municipality and conversely an higher level of saving respect to 2011, the year before the start of this program. The more municipality is close to its target (25% less than the waste management cost referred to 2011), the more people feel themselves as encouraged to differentiate waste already brought out in the system as much as possible, causing waste piled up in the landfill to decrease further. Influence of saving process about boosting the differentiation of waste already circulated, might be seen as a remarkable impulse to make the three minor balancing loops (composting, recycling, reuse⁴³) persist over time.

Finally, attitude of saving thanks to the development of such a policy over time is going to address also the habit of people to make waste at source. So saving ratio acts also at the start of the waste management chain encouraging people to make waste as little as possible, whenever they see that their efforts are rewarded by a lower level of actual cost, namely taxes.

⁴³ As seen before, the more compost and the more recycling people are used to make, the less waste municipality is going to carry in the landfill because somehow citizens succeed in retrieving the intrinsic value those products still embodied. The same is for waste reused, since the more waste they succeed in reusing the less waste piled up in the landfill is going to be pass through incineration system.

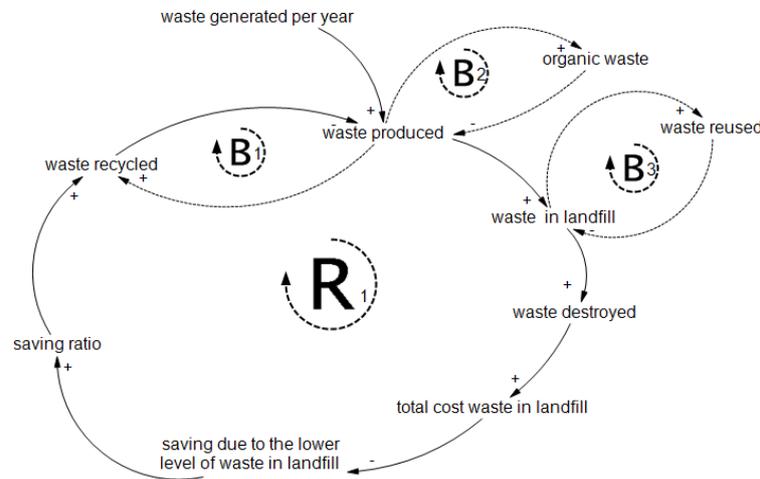


Fig. 4 Recycling loop (R1)

Otherwise, if the level of saving is lower and lower, they are less encouraged to produce less waste. This explanation constitutes the basis of legitimacy for the following graph function:

In particular, waste per person is modelled as a default value equal to 0,22 tons per person –a sort of estimation of how much waste a person is used to make on average by looking at the official data gleaned thanks to the municipality –multiplied by the effect that saving ratio can exert on the habit of recycling of each person.

This explanation constitutes the backdrop for introducing the second major causal loop (waste production loop) that, as well as the recycling loop, make the three balancing loops – designated to squeeze the amount of waste irreversibly conferred to landfill – strengthen over time.

Therefore, by diminishing the amount of waste per person, saving process is intended to decrease consequently the whole amount of waste produced each year.

5 CONCLUSIONS

Zero Waste Strategy has been a shift of paradigm that has required time to be understood and accepted by citizens. It might be seen as a double loop learning (Argyris and Schon) answer to sustainability challenge, given that by implementing this strategy, municipality seems to be more willing to look forward, to reveal an explicit mental model, to assess its consistency over time and to improve it⁴⁴ by collecting all the weak signals of change arising from the

⁴⁴ J. W. Forrester, “*Some Basic Concepts in System Dynamics*”, Sloan School of Management Massachusetts Institute of Technology, 29th January 2009, p. 10.

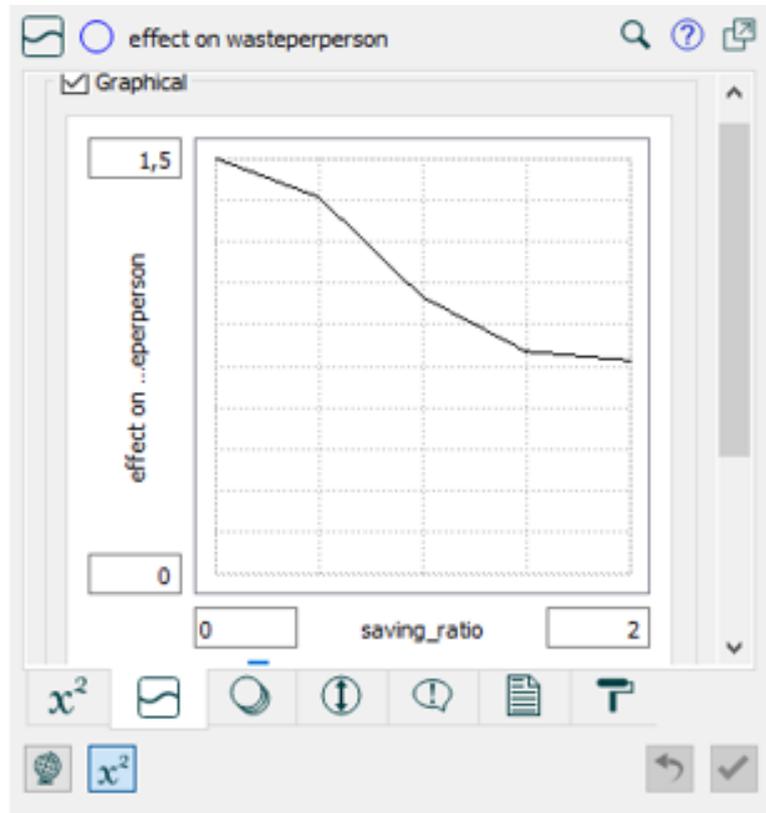


Fig. 5 Graph function “Effect on waste per person”

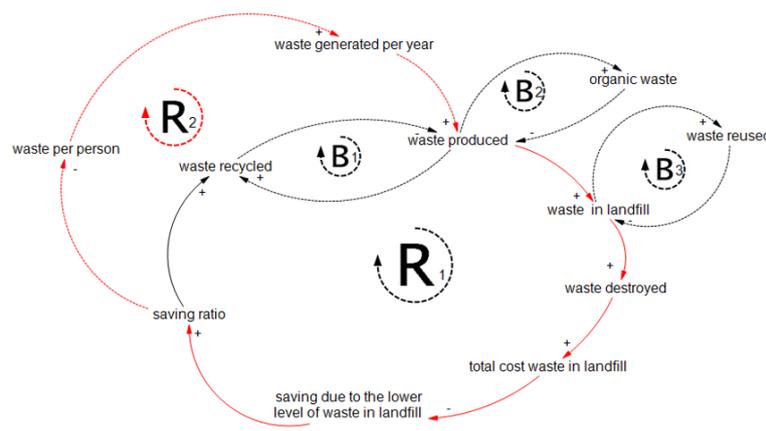


Fig. 6 Waste production loop (R2)

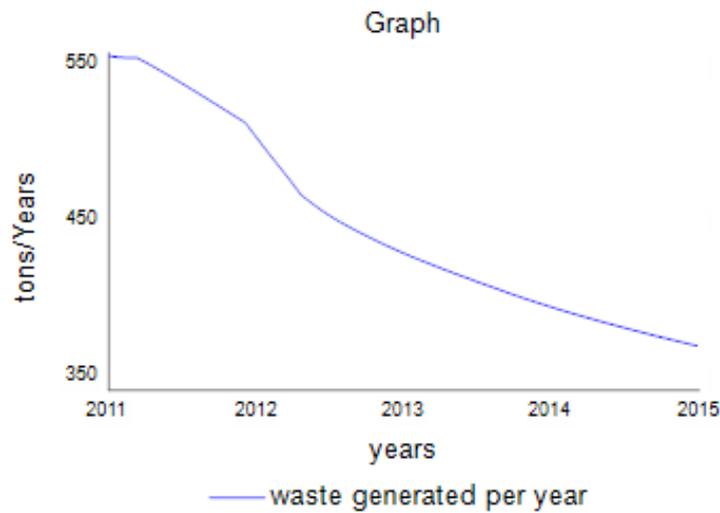


Fig. 7 Waste generated per year during the period 2011-2015

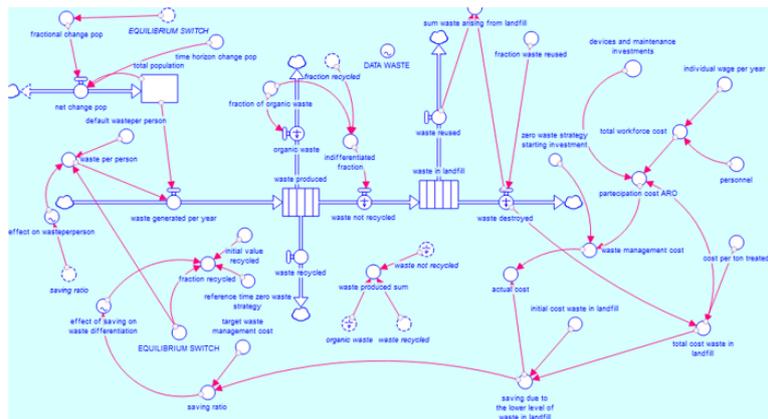


Fig. 8 The Whole SD model

outer systems. Recalling the democratic accountability paradigm conceived by Behn (2004), accountability process requires people to form expectations about performance; specifically, accountability process works letting citizens approach directly the end-results of their ongoing good practices. Actually, lower tax burden level has been crystalized as the reward of their effort to cause waste to decrease both at source and at the end of the waste chain depicted in the SD model.

That being said, given that the threshold of 65% of fraction of waste recycled might be considered as a national diktat (art. 205 Legislative Decree n. 152/06) framed within the boundaries of a preminent European objective (Directive n. 98/2008), saving process might be seen as

a facilitator, since its advertising allows to achieve this goal as soon as possible, encouraging people to still follow zero waste program.

The latter one has been becoming the input of a virtuous cycle – fostered by saving process – which has jeopardized the previous regime of living of citizens, since for example the usage of plastic dishes or disposable paper cups, traditionally reckoned as comfortable, has been discouraged. Anyway, there should be still room for fine tuning, starting for example reverse logistics initiatives as well as in Scandinavia⁴⁵. These initiatives might engage community more and also they might fuel industrial responsibility, since on the one hand firms would be forced to think further about a sustainable production; on the other hand consumers will be more and more sensitive to the environmental care. In this perspective, consortium like ARO-Valle del Sosio might be seen as a crucial bridge between community and industrial responsibility thanks to a door to door collection inspired by recycling criteria. It is important not to frustrate citizens commitment at source (by making waste as little as possible) and at the end (by differentiating waste as much as possible) avoiding to compact again waste and to send it indistinctly to landfill. Therefore, ARO together with consortia delegated for processing each type of packaging waste, will constitute the idealistic bond to let the two zero waste strategy levers (namely engaging community and industrial responsibility) match. In fact, compensations given to ARO are bound to be shifted downstream to the municipalities determining lower taxes for the citizens; this aspect will foster people more and more to make the above mentioned reinforcing loops persist over time. In addition, treatments carried out by consortia are the unavoidable starting point to enables industries to exploit these materials again.

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⁴⁵ ICA (but also other supermarkets like Meny or Rema 1000), one of the biggest supermarkets in the Northern Europe and the biggest one in Sweden is equipped with a compelling reverse logistics grounded on an equipment system in front of the gate, which could recover second-hand bottles and cans. To recover the used bottles, people can get 2 kr for each big plastic bottle, 1 kr for each small plastic bottle and beverage can. Finally, customers will get a ticket with the return money from the equipment and be available to buy things with this ticket in the supermarket. People can also choose to donate the money to charity if they want. M. GONG, Y. KONG, “*The implementation of green logistics in supermarkets in Sweden and China — A case study for ICA MAXI and JIA JIAYUE*”, 2013, p.29. Available on: <http://www.diva-portal.se/smash/get/diva2:722929/FULLTEXT01.pdf> [2017].

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