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From Waste Management to Circular Resource Management

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Abstract The circular economy is a topic researched by Wageningen University & Research (WUR). In addition to better waste management WUR strives to reduce the use of resources in its operational management. Recently WUR's executive board ratified a Circular economy policy, vision & strategy 2019-2030. Aim is to achieve a 50% reduction in the use of resources in 2030, compared to 2014. This ambition follows the circular economy policy launched by the Dutch government.By buying fewer products, making smarter use of products, extending their lifespan and re-using products within WUR or elsewhere, WUR will reduce the number of resources used, as well as the amount of waste that is incinerated or recycled. In order to follow the progress of WUR's circular economy policy WUR will also monitor the usage of resources, in addition to the current waste monitoring. Strategies proposed are to extend the use of products, to recycle products for new purposes, extending the lifespan of new products and to close the circle for new products fully. The success of WUR's circular economy policy depends on acceptance and support by, and behaviour of students and employees whose expertise WUR will furthermore use where possible. WUR will also cooperate where possible with other organisations and companies.

Keyword:

Circular economy, circularity, resources, waste management

1. Introduction

According to its mission 'To explore the potential of nature to improve the quality of life' [1], Wageningen University & Research (WUR) has sustainable development as a fundamental philosophy. Besides operationalising sustainable development in education and research, WUR also regards sustainability as an important principle in its operational management. Promoting and achieving sustainability is considered as a continuous and on-

going process.

The waste management approach at WUR is an example of how sustainability is incorporated in strategies, policies and practices. In this paper we give an insight into the steps taken within WUR to go shift from waste management towards resource management using a circular economy approach.

We will first describe WUR's strategy and policy (section 2). Section will give an insight in the current waste management practices. In section 4 we will discuss the transition from waste management to circular resource management and WUR's vision on the circular economy. We will conclude with some remarks on the results up to now and the challenges we encounter while working on the transition from waste management towards resource management (section 5).

2. Infrastructure

2.1. Waste management policy

Up to 2020 WUR waste management policies [2] did follow a waste hierarchy. In this approach priority is given to the most environmentally friendly methods of waste processing. Different steps in the hierarchy are: Reduce (prevention) - Reuse - Recycling - Recovery – Disposal. However, the focus of these policies was mainly on the safe processing of waste through recycling and incineration with energy recovery, while prevention and reuse received less attention.

WUR's policy on waste is in line with the national waste management policies of the Dutch Government. The circumstances for good waste management in the Netherlands are favourable. Together with stringent waste treatment standards and producer responsibility, the waste hierarchy in the Netherlands also known as 'ladder of Lansink- is the backbone of good waste management practices. The Dutch government implemented national policies and several programmes for waste management. In Europe, the Netherlands has established a leading position in waste management. Currently, 79% of Dutch waste is recycled and the remaining part is mostly used for energy production [3]. The amount of waste that is going to landfills decreased from 35% in 1985 to 2.1% in 2016 [4].

Since 2016 a circular economy policy approach is adopted, aiming at prevention and reduction of (abiotic) use of raw materials [5]. This basically represents a shift from waste management to resource management of which waste management is part. Fig. 1 shows the relation between the original waste hierarchy (on the right) and the strategies of the 'circularity ladder'. In the transition from a linear to a circular economy emphasis is put on smarter use of products (prevention) and extending lifespan of products and parts (reuse), with a focus on reduction of resource use [6].

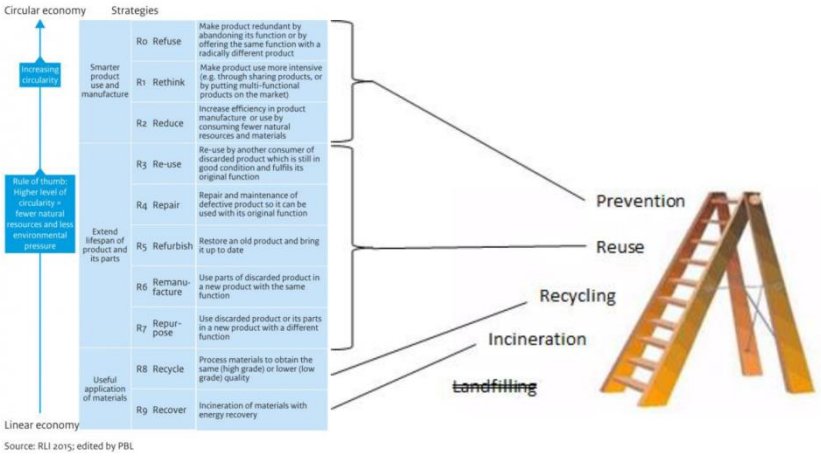

Figure1. The relationship between circularity strategies and the waste hierarchy (Ladder of Lansink).

2.2. Transition to circularity

As the circular economy is a research topic within WUR [7] and WUR's own waste management policy and practices are largely in order, the next step towards a circular economy is an obvious one. In 2018-2019 WUR worked on a new strategy on resource flows and waste management.

In 2020 the new strategy on circularity was ratified by WUR's executive board: 'Circular economy policy - Vision & strategy 2019-2030 [6]'. This vision marks the transition from a waste policy to a circular economy policy. WUR wants to halve the use of (abiotic) raw materials by 2030 compared to 2014 by abandoning products, by using products more intelligently, and by longer use (or reuse) of products. This will not only reduce WUR's use of resources and raw materials but will also diminish the amount of discarded waste [9].

3. Waste Management Implementation

3.1. Waste separation

Within WUR, waste flows are separated at the source and the waste life cycle is managed sustainably and efficiently from the source to processing. WUR discerns three main waste streams: paper, hazardous, and residual. In addition, residual waste is separated in at least 15 different waste streams, including plastics, organic waste, metals and paper coffee cups [10].

The methods of internal waste collection differ er location. In educational buildings and in most office buildings a waste separation system, EcoSmart, is implemented. An external service provider is contracted for the collection of internal non-hazardous waste. At other locations waste collection is provided by the facility services department of the university. In educational buildings and outside central collection points are positioned at strategic spots (Fig. 2, 3). In office buildings students and employees are encouraged to put their waste in the correct waste bin (Fig. 4).

Figure **2**. Waste separation on Wageningen Campus

Figure 3. Central waste collection point in an education building.

Figure 4. Separate waste collection bins in office buildings

3.2. Waste composition and processing

All waste is deposed of through specialized waste collection and processing companies. Waste that is separated at the source (within WUR) will be recycled. Part of WUR's residual waste flow will be separated for recycling after collection. The amounts and processing methods per waste flow are listed in Table 1. In 2019 a processing method that is classified as a 'useful application' applied to 95% of WUR's waste: 48% of the waste was recycled, 47% was used for a variety of other useful applications as thermal recycling and incineration with energy recovery [10].

Table 1. Total waste flows of WUR in 2014-2019 [10, 11].

Waste flow (kg)	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Business waste	1,361,400	1,291,922	1,548,002	1,538,928	1,393,294	1,770,524
Residual waste	*940,677*	*907,726*	*1,096,954*	*1,013,504*	*901,586*	*893,398*
Organic waste/green waste/swill	*119,942*	*180,450*	*193,195*	*189,616*	*223,768*	*454,413*
Construction/ demolition/rubble	*183,320*	*80,840*	*114,416*	*118,140*	*76,906*	*192,380*
Foil/plastics	*31,896*	*35,008*	*43,145*	*60,102*	*50,057*	*70,918*
Glass	*18,846*	*11,654*	*19,990*	*17,373*	*18,890*	*16,245*
Soil	*19,280*	*25,334*	*27,350*	*64,380*	*18,400*	*12,060*
Wood	*39,805*	*26,810*	*26,620*	*39,980*	*19,880*	*40,140*
Manure				*4,140*	*64,740*	*67,380*
Metals				*13,270*	*10,520*	*8,890*
Scrap	*3,060*	*9,020*	*16,290*	*3,700*	*4,340*	*5,580*
Rock wool	*3,680*	*12,380*	*9,680*	*7,180*	*3,400*	*9,120*
Oil/grease/fat/butter	*498*	*2,386*	*285*	*7,320*	*675*	
Data	*396*	*314*	*77*	*223*	*132*	
Paper waste	329,447	295,184	296,788	289,117	300,983	298,800
Hazardous waste	305,932	309,964	352,125	362,670	492,186	486,333
Total waste	**1,996,779**	**1,897,070**	**2,196,915**	**2,190,716**	**2,186,463**	**2,555,657**
Waste separation	*54%*	*52%*	*50%*	*54%*	*59%*	*65%*

Processing method per waste flow

Waste flow	***Processing method***
Glass, plastic, foil, wood, metals, rock wool, oil/grease/fat/butter	Recycling
Organic waste (garden/green/swill)	Recycling (fermentation)
Construction and demolition waste, rubble, scrap	Sorting & recycling
Old paper & cardboard, data	Shredding & recycling
Residual & bulky waste	Thermal recycling (waste incineration installations with R1 status, with energy recovery)

Waste flow (kg)	2014	2015	2016	2017	2018	2019
Hazardous waste			- In general: incineration with energy recovery. - Toxic waste: incineration in a rotary drum furnace (by specialist companies), also with energy recovery. - Animal waste: destruction, production of biofuel			

The size of the different waste streams fluctuates each year. These fluctuations are caused by changes in staff and student numbers, by shifts in research activities or organisational changes. For example, in 2019, the total amount of waste has increased significantly (+17% compared to the previous year). Organic waste did increase in particular, due to a large-scale agricultural experiment. Also, more construction and demolition waste were disposed of because of construction activities. Furthermore, the amount of waste increased after a merger with an external organisation [8].

3.3. Prevention and reduction

Preventing waste generation is an important aspect of good waste management and applies to all waste streams. Less waste means also less costs for removal. In the past few years examples of strategies for using less resources and waste reduction were:

Paper use. Two-sided printing is the default at all printing machines. The average percentage of double-sided prints is 80%. During the annual introduction days (AID) for first year students at the start of the academic year, the daily printed AID newspaper is being replaced by an AID app. Procurement, ordering and invocing procedures are carried out digitally and WUR discourages suppliers from sending unsolicited hard-copy catalogues and leaflets. As WUR deals with large numbers of orders and invoices, the use of paper, toner cartridges and postal services has been drastically reduced.

Single use plastics. Promotion of the use of reusable bottles, mugs and cups. Water taps for drinking water are placed in most buildings, staff and students are encouraged to refill their own multiple use bottles or cups.

Organic waste. In most buildings on Wageningen Campus organic waste and swill is collected separately. Through better separation the quantity of organic waste increased. Each year 600 tonnes of green waste from the greenhouses and gardens is composted on campus. This results in about 400 tons of compost, which is reused on the agricultural areas around the campus. One of these areas is the Field on Wageningen Campus, where students of Wageningen Student Farm bring their knowledge about sustainable farming into practice.

Renovation of the library. Circularity was considered as much as possible during the renovation of the library in the Forum building. Examples were the use of circular carpet and sustainable materials (including rubberwood) and the selection of Cradle2Cradle furnishings. Suppliers were expected to deliver furniture without packaging.

3.4. Waste management results

Waste monitoring has helped us to get a better insight into the composition of the waste generated by WUR. Contracted waste collection companies are obliged to weigh all waste flows and to provide management information on the amount (kg) and composition, the transport frequency and mode of disposal. Waste figures go back to 2005 and show an

improvement in the waste separation percentage. In 2019 an overall separation percentage of 65% was reached [8]. Fig. 4 presents the waste separation percentages in 2014-2019. Table 1 gives insight in the waste streams in 2014-2019. Extensive figures on waste are part of the Annual Environmental Year Report [10,11].

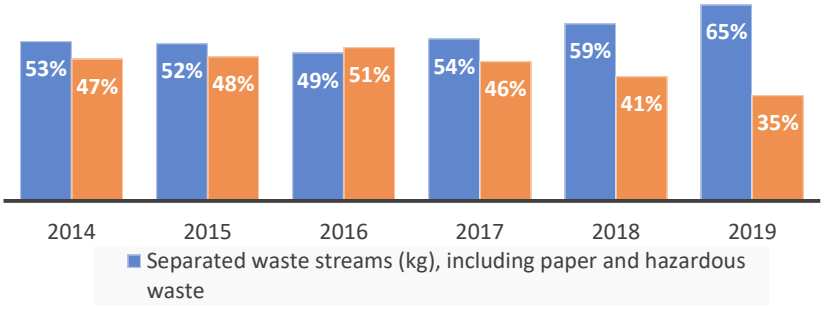

Figure 4. Waste separation percentages in 2014-2019 [10, 11].

4. Towards Circular Resource Management

4.1. Product Flow Analysis as starting point

An extensive Campus-based Product Flow Analysis (PFA) was carried out in 2019. A PFA maps all material goods and their flows, from procurement through disposal. As part of their thesis a group of students did analyse all procurement orders in 2017 and made an overview of all products that have been purchased. These product flows were compared with the flows of materials that exit the campus as waste. The results of the PFA are shown in Fig. 5. The PFA did provide a better insight into the types of products and resources used within WUR and did contribute to the development of a strategy on circularity [12].

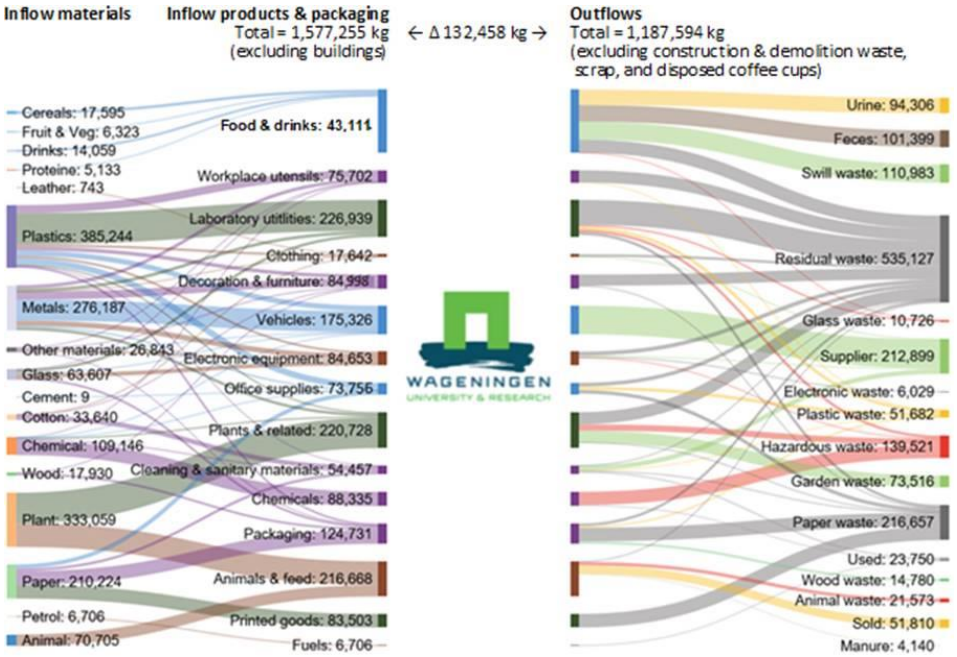

Figure 5. A campus-based Product Flow Analysis (PFA) [12]

4.2. Circularity strategies

As mentioned in §2.2 a new strategy on circularity was adopted: 'Circular economy policy - Vision & strategy 2019-2030'. To reach the ambition of a 50% reduction the use of (abiotic) raw materials in 2030, various circular strategies for the use of products are identified:

a) *Longer use and reuse of products.* This strategy is primarily useful for products that are already present in WUR's inventory. For these products the period of use will be extended or products will be recycled for new purposes, for example, extending the use of furniture, reclaiming doors and toilets from torn-down buildings.
b) *Closing the circle for new products to be purchased.* The amount of material incorporated into the product should be equal to the amount of material that can be recovered after discarding for new uses. Extending the life-span of new products is also an option, but WUR aims to close the circle for new products fully.
c) *Exploring other circular possibilities.* Circularity strategies for products that are to be acquired are considered, for example, sharing products (such as cars and smartphones) for private and professional use, multifunctional products (such as the print-fax-scan-copy machines already being used), or abandoning the use of certain products. For example: bring your own device, rather than having fixed computers in practical rooms [6].

4.3. Plans and actions

WUR's ambition is to minimize the use of new raw materials and reduce residual waste, by optimizing reuse and opting for recyclable products, separate collection of waste flows and combating food waste. To follow progress, the use of raw materials in products will be monitored in addition to the existing waste monitoring. For WUR's vision on circularity an associated action program will be implemented.

Strategies, are focused on three product groups:

1) Buildings.
2) Products for general use, such as vehicles/mobility, decoration and furniture, electrical appliances, printed matter, workshop and office equipment, cleaning and sanitation, food and beverages, work clothing.
3) Products needed explicitly for education and research (WUR's core tasks), such as laboratory equipment, plants, animals and fodder, chemicals.

The action program (or implementation program) will focus on:

- Buying fewer products and making smarter use of products by extending their lifespan and re-using products within WUR or elsewhere. In this way the number of resources used will be reduced, as well as the amount of waste that is incinerated or recycled.
- In addition to the current waste-monitoring, the usage of resources will also be monitored, so that the progress of WUR's circular economy policy is followed.
- New contracts with suppliers of the different product groups will be based on circularity strategies.
- The current waste contracts for the collection and disposal of the various waste streams will be replaced by "raw materials contracts".
- Involving contractors, as experts on circularity in their field, will help WUR find solutions to implement the circular economy policy. Collaboration in coalitions is an essential

factor in WUR's view on circularity. Also, the involvement of students and staff and use of our own scientific expertise is a crucial factor [6].

5. Concluding Remarks

Wageningen University & Research produces approximately 2 kilotonnes of waste each year. Over the past few years emphasis was put on good waste management. Extensive management information on the types and quantities of waste helped to identify possibilities for improvement. This has led to better internal waste collection and more separate waste flows. More waste could be offered for recycling, while the remaining part was incinerated with energy recovery. However, more can be done to go 'higher up the circularity ladder' by focusing more on prevention and reuse. It is clear that reducing and reusing resources (products) will have the highest impact in diminishing the environmental pressure of waste.

In 2019, WUR developed a vision on circularity. This vision marks the transition from a waste management policy to a circular economy policy. In line with the Dutch government policies, WUR aims at a 50% reduction of the use of (abiotic) raw materials policies in 2030 compared to 2014. With this new strategy WUR will reduce the consumption of raw materials, what will also have an effect on the waste volume. A reduction of 50% of waste is expected.

WUR's strategy on circularity is still in an early stage. For some parts of the strategy action plans are already made, for other elements we still have to explore how to get the transition done. The switch from thinking in terms of waste and recycling towards looking at raw materials and products will be a challenging one. Challenges are:

- To involve staff and students to create circularity awareness
- To integrate operations and WUR knowledge and make good use of our own expertise on circular economy
- To include circularity strategies in new contracts with suppliers, which includes the design of new forms of partnerships to team up with circular companies and organisations
- To use the momentum of the worldwide corona crisis to keep our emissions low after the crisis.

We are aware that this transition will not happen automatically. It is a big step: going from waste management with a focus on recycling and recovery to a circular strategy based on reduction and reuse of products and resources. The switch to circularity has consequences for everyone in our organization. It is a new way of looking at incoming products and the way its resources are used again and again, and not ending up as waste.

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