Material Flow Analysis and Resource Recovery Potential Analysis of Kenyan biowaste: Case study of banana, Irish potato and coconut wastes

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Introduction

In Kenya, and similarly to many other (developing) countries where agriculture is a key economic activity, a significant amount of bio-waste is generated and are often left in the farm, burned or disposed of in open landfill, directly contributing to environmental pollution and at the same time breeds disease vectors, thus, presenting a health concern (UNDP, 2016). Thus, this bio waste on one hand, is a waste management problem, but on the other hand, it is an opportunity for creating a sustainable bioeconomy. Therefore, this study explores the possibility of recovering bioresources from Kenyan bio-waste, as such, creating value to the wastes and at the same time contributing to the waste management.

Selection of the case study: The case study was selected after a broad inventory assessment of fruit, vegetable and nut wastes in Kenya. The selection was done based on two factors, being, waste stream that has the highest waste biomass quantity potential and the inherent difference (i.e. dry versus wet and soil versus above ground) of wastes. Therefore, Banana (*Mussa* spp.), Irish potato (*Solanum tuberosum* L.) and coconut (*Cocos nucifera* L.) were selected.

Material and method

In the beginning, the occurrence, current application and disposal trends of the three selected biomass types was quantified. The occurrence of the wastes was determined through Kenyan agricultural production and supply chain analysis, while the current use and disposal trends were conducted through a literature search. After, the mass flows of these wastes were systematically tracked using material flow analysis (MFA). For the MFA, the system boundery was defined by spatial border of Kenya, the temporal boundary was the year 2018, while the functional unit was the total quantity of produce in 2018, being 1447 kt for bananas, 1870 kt for potatoes and 105 kt for coconut (FAOSTAT, 2019). Further, the quality of data used in the analysis was assessed by the Data Quality Assessment analysis approach, which is similar to the pedigree-matrix (Weidema and Wesnæs, 1996) and that was recently also proposed by Godoy et al. 2020 (Godoy León and Dewulf, 2020) as a way to assess uncertainty in MFA. The assessment indicated that the data points used ware of high to very high quality, thus the study was able to collect reliable data. Lastly, the biomolecules, biomaterials and bioenergy recovery potential from these waste streams were evaluated. To achieve this, a literature search was done on the concentrations of recoverable components and bioenergy potential. For the purpose of this study, and in the Kenyan context, the recoverable bioresorces were classified into four recovery groups: high value compounds (e.g. phenolic materials), extractable (macro)compounds for use in feed and food (such as protein, starch and sugar), macrocompounds to be used as technical materials for industrial applications (such as fibers, cellulose and lignin), and bioenergy potential (such as biogas and bioethanol potential).

Result and discussion

The study showed (Fig. 1, showing result for banana waste stream) that, large quantities of banana (6007 kt), Irish potato (426 kt) and coconut (50 kt) biomass goes to waste. Further, the study revealed that, all these wastes have potential to be biorefined (Table 2. shows potential bioresource from banana waste streams) to recover flavonoids

(74 kt), starch (377 kt), cellulose (2001 kt) and biogas (1757 GWh), being the potential total amounts of the main bioresources from the three waste streams.

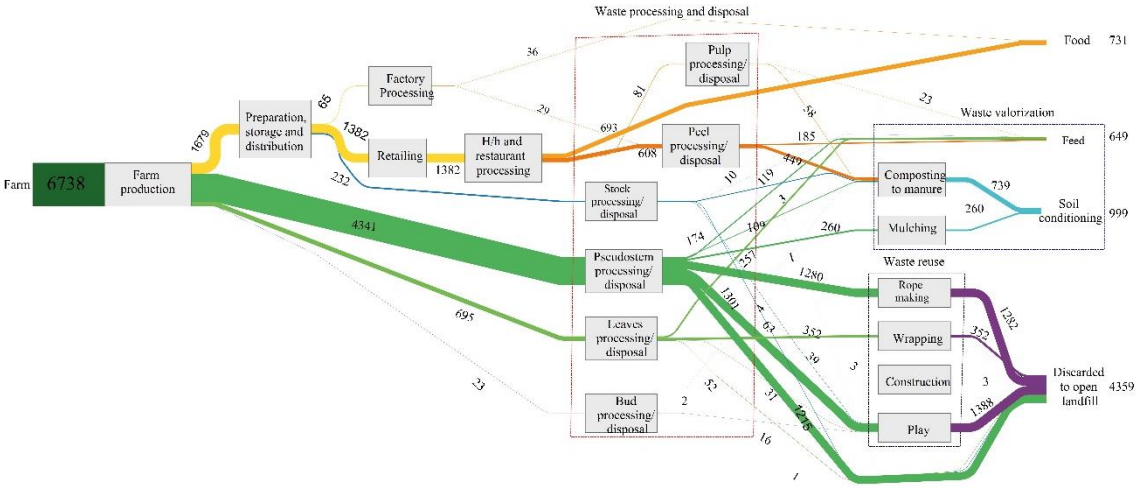

Fig. 1. MFA diagram of banana by-products in fresh weight basis

Table 1. Potential quantity of bioresource refinable from banana waste streams

Biomass	High value compounds (kt)		Extractable (macro)compounds for use in feed and food (kt)			Macrocompounds used as technical materials for industrial applications (kt)			Bioenergy potential (GWh)	
	Flavonoid	Tannin	Starch	Protein	Sugar	Fiber	Cellulose	Lignin	Biogas* (GWh)	Bioethanol** (GWh)
Peel	34.9	8.3	71.2	13.4	2.1	limited	23.3	24.9	305.4	34.4
Stem	33.9	limited	241.0	31.0	113.3	476.1	1670.4	250.5	981.7	189.7
Stock	1.5	0.9	0.8	5.9	limited	9.8	15.3	9.2	70.7	26.8
Leaves	3.8	limited	1.2	1.5	6.5	2.8	247.3	73.5	91.6	28.8
Pulp	0.1	0.2	26.6	1.5	1.4	limited	limited	limited	69.0	19.2
Male bud	limited	limited	limited	0.7	1.4	limited	2.4	0.6	6.8	0.7

Conclusion

The study, generally concluded that, there is a huge bioeconomy and waste management reduction prospective in Kenya, which can be achieved through proper waste collection, sorting and valorisation.

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