Recycling as a Tool for Resource Management - A Structural Revisit to The Material Balance Model

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Abstract— Robert U. Ayres and Allen V. Kneese presented a material flow model in a seminal paper titled "Production, Consumption and Externalities" in 1969, which had shown the transformation of material outputs into wanted and unwanted outputs. All the material outputs are from environment in which the consumers and producers co – exist. Every activity of consumption and production take place in the environment itself and wastage generated will also return to the environment itself. Recycling is a possibility of prolonging the usage of natural resources to the maximum, and there are many such interpretations available. The present study aims to offer more clarity in terms of recycling, by pointing each possibility of wastage and subsequent recycling, with a diagrammatic and mathematical explanation.

Keywords: Environmental Economics, Resource, Environment, Production, Consumption, Wastage, Recycling.

I. THE BASIC INTERPRETATION

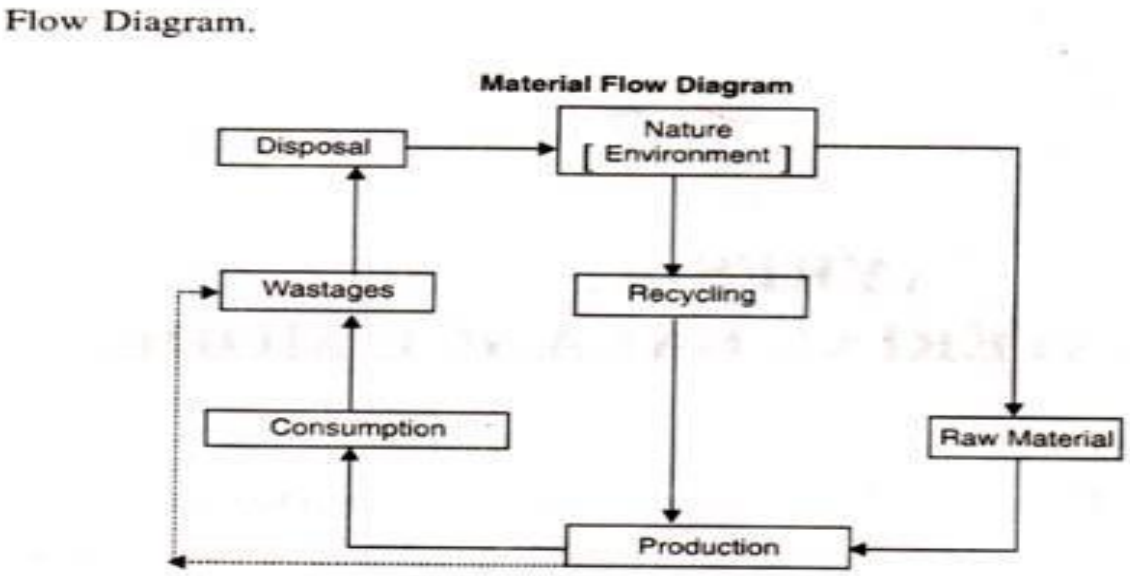

Fig. 1 - Source: Explanation of Material Balance model by Smriti Chand

The simple explanation of material balance flow diagram is that every resource originates in the environment – the system which account for the existence of known life – with humans taking the dominant status. It is to be noted that all living beings are consumers, and complement to natural production. In the economic scenario, let us focus on human activities. All are consumers and some take the initiative of producing goods, the activities of which are possible through utilization of natural materials. Consumption of goods from the producers then take place. Both the production and subsequent consumption activities generate wastage, which are then disposed in the structure of environment. Thus, the resource transfer take place and forms a complete circulation in the environment itself.

II. HOW AN EXPANDED MATERIAL FLOW DIAGRAM LOOKS LIKE?

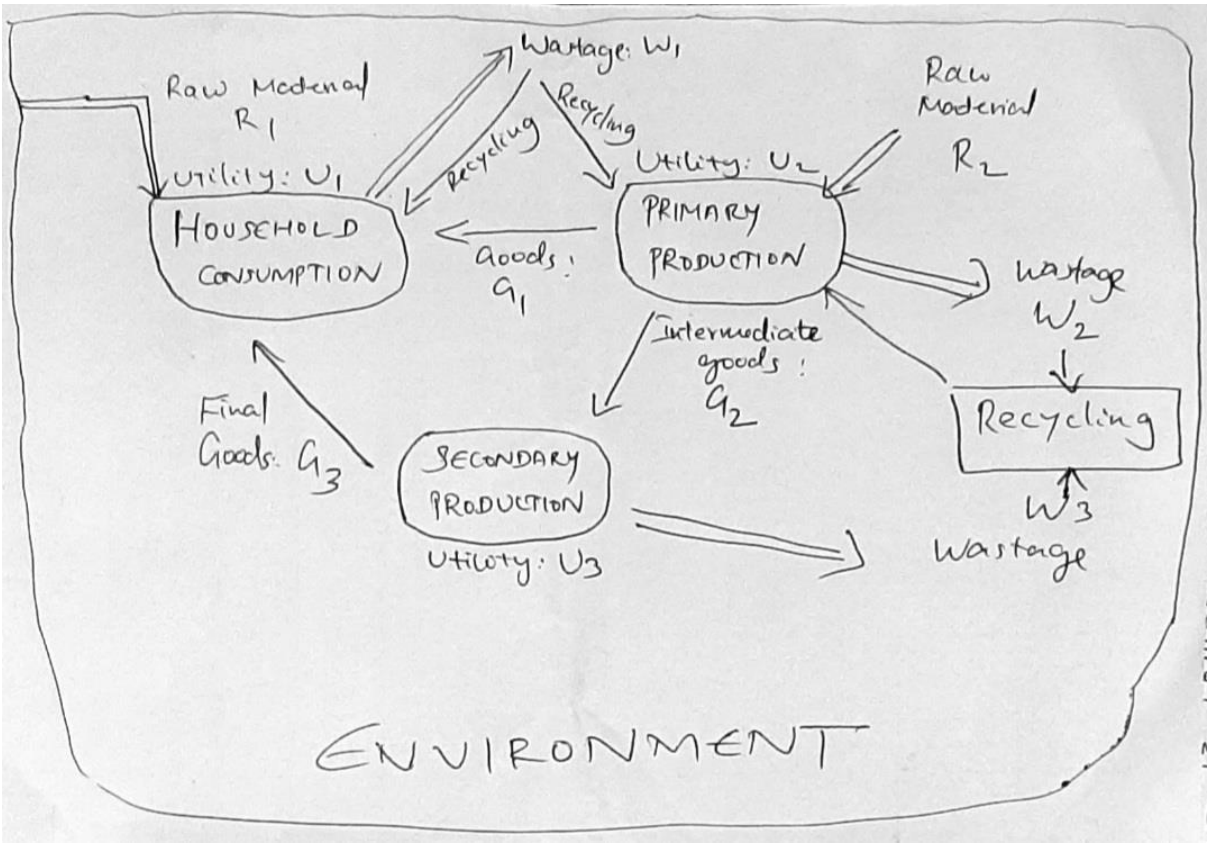

Fig. 2 - Researcher's Interpretation

We assume the same proceedings as in the simple model, with some extended activities. The concept of utility is another introduction.

From the environment, the household get inputs to consume in the form of raw materials, which could be denoted as R1. They generate utility U1. They will dispose their wastage back to environment (W1). We could assume a possibility of recycling in some cases. In an extended view, the primary producers may purchase some wastage, which they get recycled and take for their production purpose. However, they get the major share of inputs from nature, which we could refer R2. The wastage they generate is W2, which will again be subject to recycling. Their utility generated will be U2.

Primary producers have two options – to sell their goods to household. Such goods are classified as G1. Another option is to sell their products as intermediary goods – G2, for secondary producers.

In the Secondary Production stage, G2 will be used as inputs to produce final consumable goods. Here, the activities generate some utility (U3). The wastage generated shall be classified as W3, again subject to recycling. Note that W3 will be potentially recycled to form intermediate goods, thereby adding to the already existing process.

Final goods G3 will be utilised by households, from which they generate utility and wastage disposal happens again.

The conclusion is that material balance holds valid even in the combined case of multiple production possibilities and recycling methods. The process of production and consumption move on in a chain of actions.

III. MATHMATICAL INTERPRETATION

Since the natural resources are direct inputs to generate goods for consumption and production,

R1 + R2 = G1 + G2 + G3 ---------- (1)

Usage of goods generate utility and the balance material turns into wastage

Therefore, G1 + G2 + G3 = U1 + W1 + U2 + W2 + U3 + W3

Or, G1 + G2 + G3 = (U1 + U2 + U3) + (W1 + W2 + W3) ---------- (2)

For an aggregate interpretation, let's introduce the variable T for each total case

Therefore, **G(T) = U(T) + W(T)** ---------- (3)

IV. LIMITATIONS OF THE MODEL

1. In the original version, there's no indication of utility in any case. Here, in this attempt to expand the model, utility is introduced since every act of resource utilization release utility and also wastage. In this case, limitation is regarding the status of utility, as it is only a technical expression.
2. Multiple possibilities of recycling generally exist in theory, since the possibilities carry operational cost.
3. Reycling, in general, is not a hopeful situation for everyone. There are practical limitations.
4. In the modern context, the fundamental idea of resource utilization in environment is challenged in not so rare cases. If a person take part in consumption process and then proceed to outer space as an astronaut, utility will be exhausted outside the spectrum of material balance model, which breaks the logic of concept itself.
5. The striking limitation is regarding the quantitative flow in terms of material balance. The equation that has been generated as **G(T) = U(T) + W(T)** does not sound logical in terms of the quantity utilized in each case.

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