



## Review

# An overview of food waste management in developing countries: Current status and future perspective



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## ABSTRACT

Food waste (FW) related issues in developing countries is currently considered to be a major threatening factor for sustainable development and FW management systems. Due to incomplete FW management systems, many developing countries are facing challenges, such as environmental and sanitary problems that are caused by FW. The difference in FW generation trends between developing countries and developed countries was reviewed in this work, which demonstrated that the effects of income level, population growth, and public participation in FW management are very important. Thus, this work aimed to provide an overview of recycling activities, related regulations, and current FW treatment technology in developing countries by following some case studies. Taiwan, has been suggested as being a successful case in terms of FW management, and is therefore a typical model for developing countries to follow. Finally, an integrative management system as a suitable model for FW management has been suggested for developing countries.

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## 1. Introduction

Food waste (FW) sources in the literature, according to the [European Commission \(2014\)](#), have been classified into three categories: "(i) food losses: food products lost during the production phase; (ii) unavoidable food waste: referring to food products lost during the consumption phase (banana peels, fruit cores, etc); (iii) avoidable food waste: products that could have been eaten, but were lost during the consumption phase." Depending on each phase of the food supply chain, [Gustavsson et al. \(2011\)](#) separated FW into five generation sources: agricultural production, post-harvest handling and storage, processing, distribution and consumption. This work mainly reviews the FW issue where it could be avoidably or unavoidably wasted during the consumption phase. Hence, the suitable definition of FW in this study could follow the definition forwarded by [Parfitt et al. \(2010\)](#) as "food losses occurring at the end of the food chain (retail and final consumption), which relates to retailers' and consumers' behavior," or by [Brian](#)

[et al. \(2013\)](#) as: "food that is of good quality and fit for human consumption but that does not get consumed because it is discarded either before or after it spoils. Food waste typically, but not exclusively, occurs at the retail and consumption stages in the food value chain and is the result of negligence or a conscious decision to throw food away."

The Gross National Income (GNI) is used to separate the dividing line between developing and developed countries. This GNI is one of main factors relating to the generation rate of FW of a country ([Adhikari et al., 2006](#)). According to the [International Statistical Institute \(2014\)](#), developing countries are defined according to their GNI per capita per year. Countries with GNI of US\$11,905 and less are defined as developing countries. The present study refers the most recent list of developing countries cited by the [International Statistical Institute \(2014\)](#).

In general, developing countries are facing relatively greater challenges in FW management than developed countries. FW is currently an environmental issue because it is not segregated well from Municipal Solid Waste (MSW), which contributed to increasing greenhouse gas (GHG) emissions in landfills. According to [Isabelle Denis \(2014\)](#) (FAO Liaison Office in Brussels), FW might produce greenhouse gas emissions and therefore has an impact on climate change. Thereafter so countries must identify and

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### Nomenclature

3Rs	reduction – reuse – recycle
AD	anaerobic digestion
EPA	Environmental Protection Administration
EU	European Union
FW	food waste
GFN	Global Foodbank Network
GHG	greenhouse gas
GNI	Gross National Income
ISI	International Statistical Institute
KWh	kilowatt-hour
MWh	megawatt-hour
MSW	multiple solid waste
NEA	National Environment Agency
NGO's	Non-Governmental Organizations
PAYT	pay as you throw
SWPCM	Solid Waste and Public Cleansing Management
US\$	United States Dollar
WRAP	Waste and Resources Action Programme

implement the important FW management tasks, including prevention, recycling and disposal. An overview of FW management is helpful in solving FW problems in developing countries. This study aims at reviewing the current generation of FW, policies and regulations, treatment or disposal, and also provides future considerations relating to FW management in developing countries.

## 2. Current status of food waste management in developing countries

### 2.1. Food waste generation

FW generation can be expressed as the total weight of FW per year (tonne/year) and per capita (kg/year or kg/day). The per capita FW by consumers in Europe and North America is 95–115 kg/year, and is 6–11 kg/year in sub-Saharan Africa and South/Southeast Asia (Gustavsson et al., 2011). Recently, Thi et al. (2014) reported that the per capita FW in developed countries and developing countries are 107 kg/year and 56 kg/year, respectively. These values show that FW generation between the developed and developing countries are quite evident with higher living standards resulting in greater FW generation (Brian et al., 2013). This could be explained based on the fact that higher living standards correspond to higher quality and aesthetic standards of food products among consumers in developed countries. Therefore, this results in large amounts of FW generation to meet the food quality demands, such as greater numbers of ingredients that will be needed to produce high quality food. Moreover, consumers could influence the amount of FW produced by retailers. FW- Food products, that are not sold or are expired will be disposed instead of donating it to food banks or charity organizations (Commission European, 2014).

Societies with low living standards have lower quality demands for food production, and therefore, the related FW generation per capita is low. However, due to the influence of growing populations and increasing economic challenges, it is assumed that the total FW amount in developing countries is not far less than that in developed countries. The Agriculture Organization of the United Nations (2014) has reported that the annual total amounts of global FW generation is approximately 1.3 billion tonnes per year, with there being no marked difference between those in developed (670 million tonnes) and developing (630 million tonnes) countries. This

result was causing by the current higher populations and greater number of developing countries (assuming underdeveloped economies range from being are booming to developing). At present, the worldwide population in the more developed countries is 1.2 billion, and 6 billion in less developed countries (Bureau Population Reference, 2014). There are a total number of 137 developing countries and 49 developed countries. Among developing countries, especially, China and India, contribute 37% of the total worldwide population (Bureau Population Reference, 2014). Therefore, even though FW generation in developing countries is low and there is less food demand consumption, the total FW generation of developing countries is almost equal to that of developed countries.

In order to estimate the current status of FW generation according to amounts in developing countries, this review collected the official FW generation data in some developing countries and developed countries on different continents. Because FW generation pertains to the population growth rate and the GNI index (Adhikari et al., 2006), the present study discussed the country data mainly based on the GNI index. The overview of a FW generation scenario is shown in Table 1. Accordingly, FW in developing countries typically amounted to 50–55% of municipal solid waste (MSW) (Alexis and James, 2009). Table 1 also shows that the portions of FW in MSW in Brazil, Malaysia, Mexico and India were 54.9%, 55%, 52% and 51%, respectively. The high organic fraction indicates high convenience to obtain composting as a FW treatment method in developing nations. Moreover, it has been estimated that the global urban FW is going to increase by 44% between 2005 and 2025 (Antonis, 2013). Due to the rapid economic development that is mostly expected in Asian nations, it is predicted that the largest increase of FW generation in Asia could be from 278 million to 416 million tonnes, which would contribute to global anthropogenic emissions ranging from 8% to 10% (Antonis, 2013).

Fig. 1 presents the relationship between GNI per capita and FW per capita in some countries. The trend of FW generation showed that there is a correlation between the income levels (GNI per capita) and the FW generation rate. In developed countries, the trend of FW generation-based GNI is separated into two groups. In the first group, FW generation slowly decreases in correlation with the income level (GNI higher than US\$42,000), while the second group FW generation tends to increase (GNI lower than US\$42,000). The reasons that distinguish FW generation per capita into two groups are influenced by “zero waste” application. The first group is determined by higher GNI's as developed countries, which are currently adopting a “zero waste” policy to manage their waste, such as in Australia, the United States, Sweden (Song et al., 2014; Swedish Institute, 2014). The principles of “zero waste” in FW focus on increasing the diversion rate and reducing waste generation during the production processes. Waste generation in countries that have “zero waste” policy could mostly approach zero waste, and hence, their real FW generation per capita should slowly decrease (Song et al., 2014). Meanwhile, other developed countries have not moved toward “zero waste” adoption, and therefore, their FW generation per capita is high due to the diversion rate of FW being low, while virgin waste generation during production processes is high.

In developing countries, on the other hand, the FW generation trend seems to follow the rule where the wealthier the nations (high GNI per capita), the higher the waste generations (FW per capita). The relative factors on the FW generation rate in developing countries are the population growth and the speed of urbanization, which are related to income levels (Adhikari et al., 2006). For instance, the highest FW generation rate is 0.19 kg/day in Costa Rica (small scale population), and the lowest is 0.06 kg/day in India

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