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## **A new management scheme to support reverse logistics processes in the agrifood distribution sector**

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### **Abstract**

During the last decades, reverse logistics and reuse of products have received growing attention as profitable and sustainable business strategies. Looking at the agrifood distribution sector, every day thousands of agrifood stores throw away large quantities of food product no longer suitable for sale. This “waste product”, in the majority of cases, could still find new uses as animal feed or fertilizer. The return flow of food product is a typical problem of reverse logistics. This study proposes a new bi-modular scheme for managing the process of collection of “food waste” resulting from the agribusiness distribution sector and its subsequent distribution to livestock farms and collection centers located in the area of interest. The proposed management scheme consists of two modules:

- module 1: to cluster the observed area into convenient collection sectors by means of clustering algorithms;
- module 2: to identify optimal retrieval routes within each cluster by using Vehicle Routing models.

The province of Cagliari in Sardinia (Italy) has been identified as test area. An extensive data collection process has been performed in order to collect the information necessary to portray the existing scenario. The following businesses have been recorded: grocery stores and supermarkets with at least 400 sqm of retail area, livestock farms with at least 200 heads of cattle, feed mills. A number of variables concerning location, type, size and demand data have been collected for each recorded unit. The management scheme has been implemented in a software platform and successfully applied in the test area. The outcome provides useful insights to stakeholders and suggests avenues for further research in the area in order to develop a more general and intuitive tool for managing reverse logistics processes in agrifood chains.

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## 1. Introduction

Reduction of food waste and increase in resource use efficiency are receiving growing attention as profitable and sustainable business strategies. Focusing in particular on the agrifood distribution chain the extent of the food waste problem appears relevant. In Italy alone every year grocery stores and supermarkets fail to sell on average between 1 and 1.2 percent of their turnover, corresponding to around 244 thousand tons of food product that are thrown away each year (FBAO, 2013). A recent study involving British food markets estimates an amount of 366 thousand tons of waste per annum at the retail and distribution stage (WRAP, 2010). This means that every day thousands of agrifood stores throw large quantities of food product no longer suitable for sale; this “waste product”, in the majority of cases, could still find new uses as animal feed or fertilizer. The return flow of food products is a typical problem of reverse logistics that refers to the distribution activities involved in food-packaging returns, recycling/recovery, reuse and/or disposal. Such return flow involves the collection of food products and packages at retail outlets, the transfer and consolidation at collection facilities, and finally the recovery of returned products/packages (Accorsi et al., 2011; Das and Chowdhury, 2012).

Most of the research concerning food distribution networks has focused only on one specific aspect of the problem: the facility location problem, the waste allocation problem or the vehicle routing problem (Manzini and Accorsi, 2013). Comprehensive reviews on operational issues in distribution planning can be found in Manzini (2012) and Bartholdi and Hackman (2011). However, the complexity of the activities involved makes the adoption of new and integrated tools and methodologies desirable to support decision making throughout the operations management associated therewith (Filip and Duta, 2015).

In the attempt to respond to the need for integrated tools, this study aims to propose a new bi-modular scheme for supporting the management of logistics processes for collecting agrifood waste produced by the agribusiness distribution sector and its subsequent distribution to livestock farms and feed mills, where it can find a new use as animal feed. The proposed management scheme consists of two distinct but strongly related modules:

- in the first module, in order to optimally plan the waste collection process and to be able to better organize the subsequent distribution to farms and collection facilities, the test area has been divided into sub-aggregates of businesses using clustering algorithms;
- in the second module, by considering independently the various clusters detected in the first module, several variations of the vehicle routing problem have been applied in order to identify the most convenient way to serve the various nodes in each cluster using a fleet of vehicles with limited capacity.

The proposed two-step approach has been implemented in a software platform which can support the decision making process of stakeholders and practitioners for the management of real instances from the agrifood distribution sector. As an example of real application this study illustrates the results of applying the proposed management scheme to the province of Cagliari in Sardinia (Italy).

The structure of the study is as follows: section 2 presents a brief literature review on management models for reverse logistics processes, section 3 describes the logistics problem examined, section 4 illustrates the adopted methodology, section 5 presents the area and the test data and discusses the computational results of the application. Finally section 6 concludes the paper.

## 2. State of the art

The return flow of food products is a typical problem of reverse logistics and concerns distribution activities involved in food-packaging returns, recycling/recovery, reuse and/or disposal. Reverse logistics activities are often

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