Using GIS tools to support decision making on location when a firm wants to add a new store

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Abstract

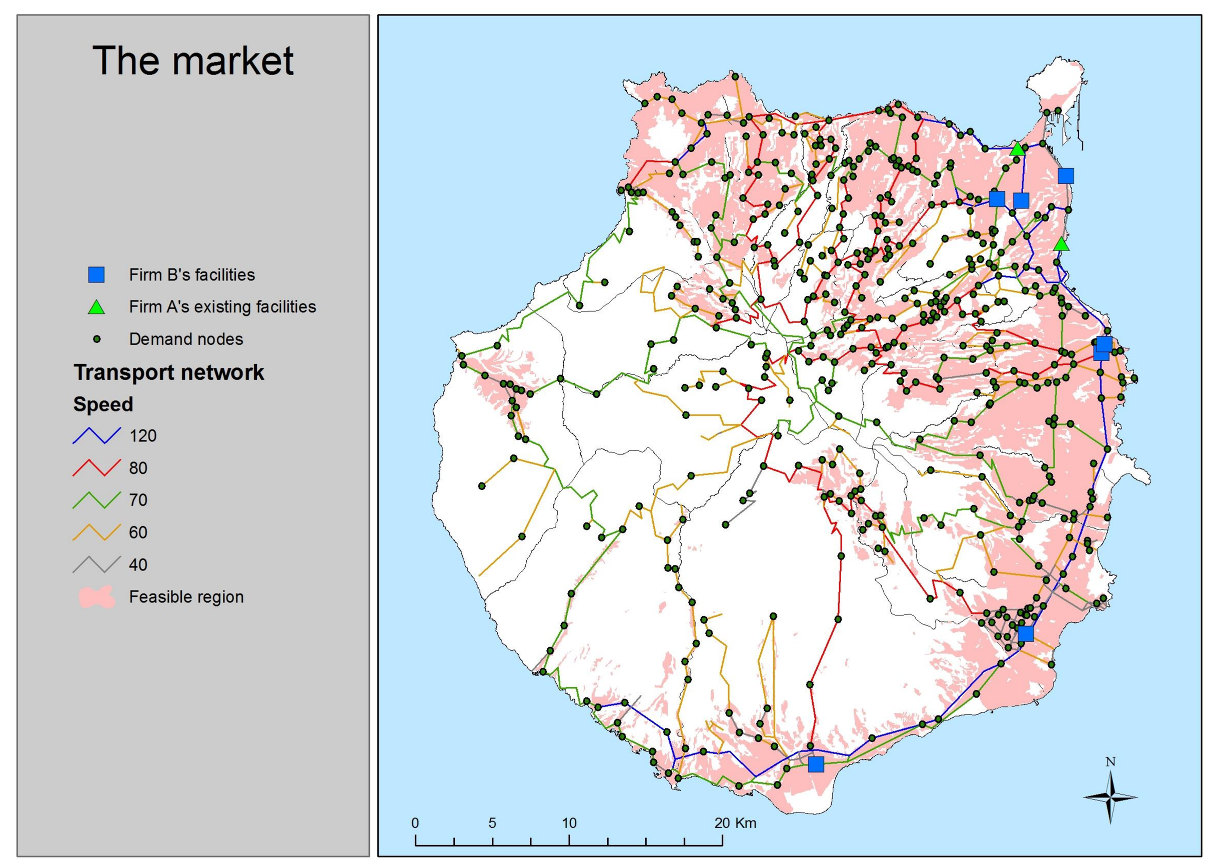
This paper deals with a network competitive localization problem in which a firm seeks to determine the location of a new facility. This new facility must compete with all the facilities operating in the market, both belonging to the same firm and to the competing firms. It is assume that the new facility can be located at any point in a transport network and that customers' preferences are proportional. In this context, two frequently conflicting objectives are involved: maximization of the total market share captured by the firm and minimization of market share losses for its existing facilities due to being captured by the new firm (cannibalization). We present a GIS tool that provides both a map representing the market share and a map showing the cannibalization effect, or a combination of these two maps. These maps provide significant aid to the decision maker in the location problem. GIS tools allow incorporation of forbidden regions and other restrictions as well as visualization of the effects produced by the opening of a new facility in the market and the trade-offs between the objectives.

The model:
Let $N(V,E)$ be a weighted network with node set $V=\{v_i\}_{i=1}^n$ and edge set E, where each node v has associated a weight $w(v)$ and each edge e in E has associated a cost $c(e)$. It is assumed that $N(V,E)$ represents a market where $w(v)$ is the demand (or buying power) at node v and $c(e)$ represents the unitary transportation cost along the edge For points x, y in $N(V,E)$, $c(x,y)$ is the cost of the minimum cost path joining x and y.
The attraction felt by customers at node v towards a facility j at x_j with quality level a_j is given by

$$a_{vj}=\frac{a_j^\alpha}{c\left(v,x_j\right)^\lambda},$$

where α and λ are parameters that reflect the effect on the customer's behavior of size and transportation cost, respectively.
Let $V^d\subseteq V$ be the set of network nodes where demand exists , $V^A(V^B)\subseteq V$ the sets of network nodes where a facilities of firm A (B) already exists and $c_{ij}=c(v_i,v_j)$,
Then, following the Huff model, the market share captured by a facility with quality level a_j located at point at x_j is given by

$$M(x_j)=\sum_{v_i\in V^d} w(v_i)\frac{\dfrac{a_j^\alpha}{c\left(x_j,v_i\right)^\lambda}}{\dfrac{a_j^\alpha}{c\left(x_j,v_i\right)^\lambda}+\displaystyle\sum_{v_j\in V^A\cup V^B}\dfrac{a_j^\alpha}{\left(c_{ij}\right)^\lambda}}.$$



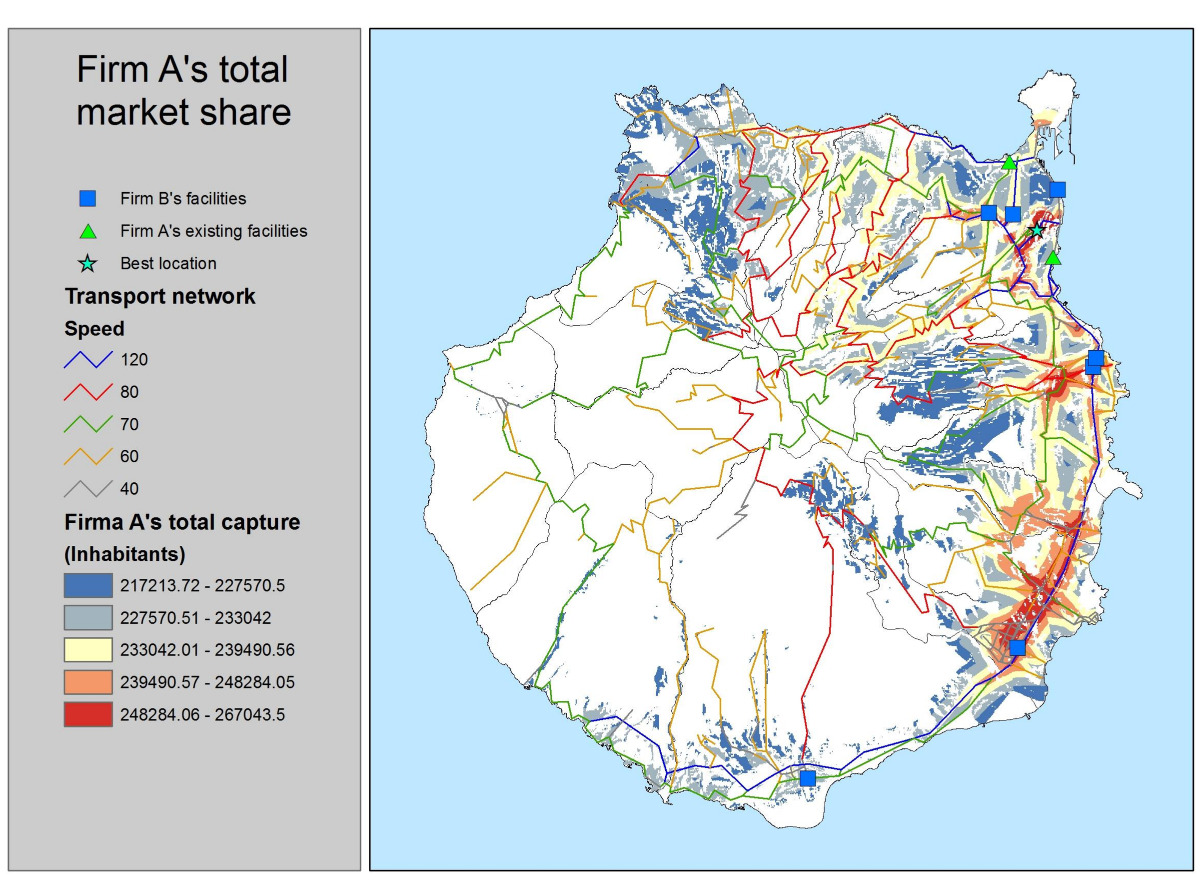
The problem:
There is a market where nine hypermarkets are competing. Two stores belong to Firm A (green triangles in the figure) and the rest (blue squares) belong to Firm B.

The demand is non-elastic and is aggregated at some nodes of the transportation network.

A buffer of 3 kms. radius around the transportation network has been considered as feasible region. Forbidden areas, such as water bodies or natural protected areas, has been removed from this buffer.

Firm A seeks to locate a new store. To do this, both the total market share and the cannibalization produced over its existing facilities must been took into account.

The process:
The GIS information related to the market (demand, transportation network, existing facilities) was converted in ASCII format. Then, this information was treated using a C-coded program to evaluate the different objectives in the feasible region. The C-program results can be imported by ArcGIS to obtain different maps where the different objectives are represented.



Firm A's total market share (TM): Capture obtained by Firm A considering both the existing and the new hypermarkets.

$$TM(x_0)=\sum_{v_i\in V^d} w(v_i)\frac{\dfrac{a_0^\alpha}{c\left(x_0,v_i\right)^\lambda}+\displaystyle\sum_{v_j\in V^A}\dfrac{a_j^\alpha}{\left(c_{ij}\right)^\lambda}}{\dfrac{a_0^\alpha}{c\left(x_0,v_i\right)^\lambda}+\displaystyle\sum_{v_j\in V^A\cup V^B}\dfrac{a_j^\alpha}{\left(c_{ij}\right)^\lambda}}.$$

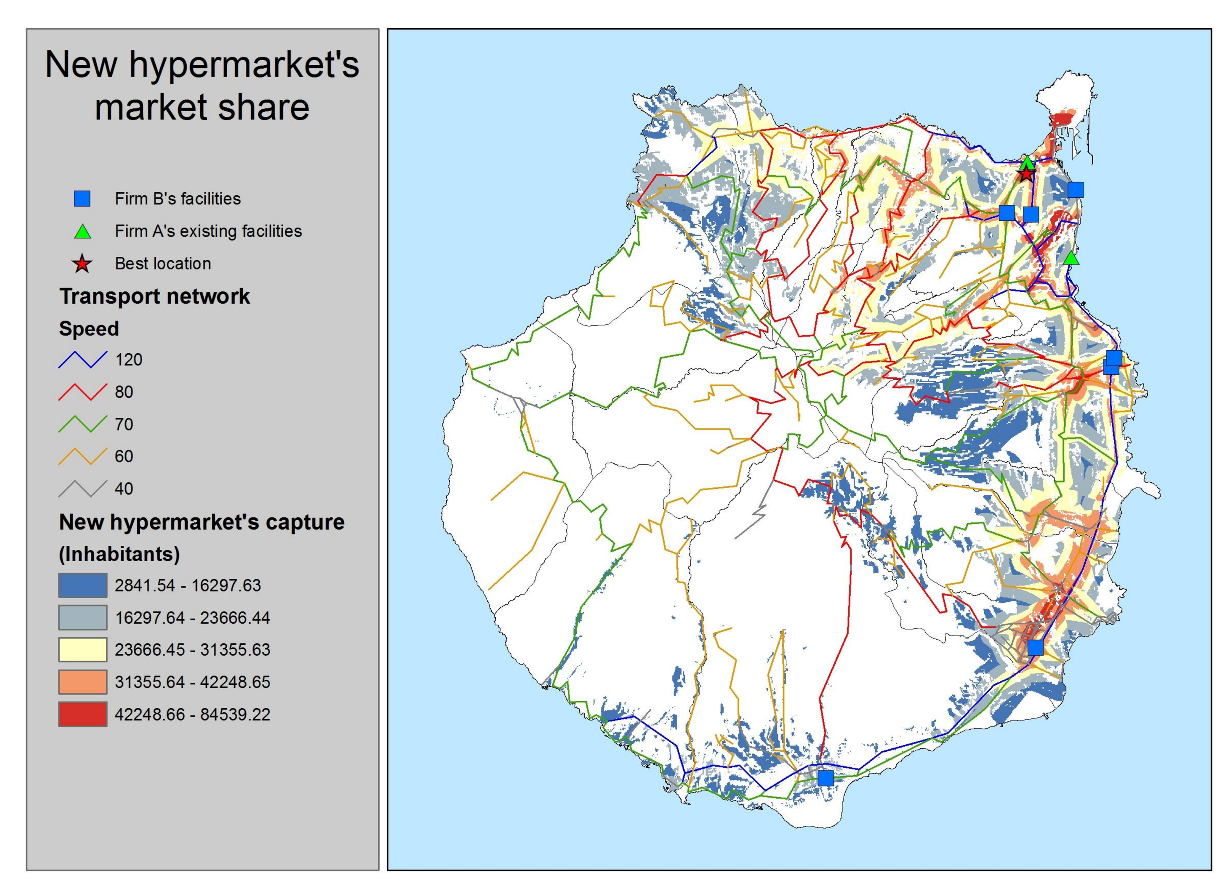
The location that maximizes this function (the red star) is in the capital of the island, in a zone between facilities belonging to both firms A and B.

Results:
Some raster maps are obtained. In these maps, for every point in the feasible region, the following objectives are shown:

- Firm A's total market share.
- New hypermarket's market share.
- Cannibalization maps for every exiting facility belonging to Firm A.

The maps not only allows us to find the areas where an objective is optimized but also gives the decision makers a tool for comparing the suitability of the different areas in the feasible region.

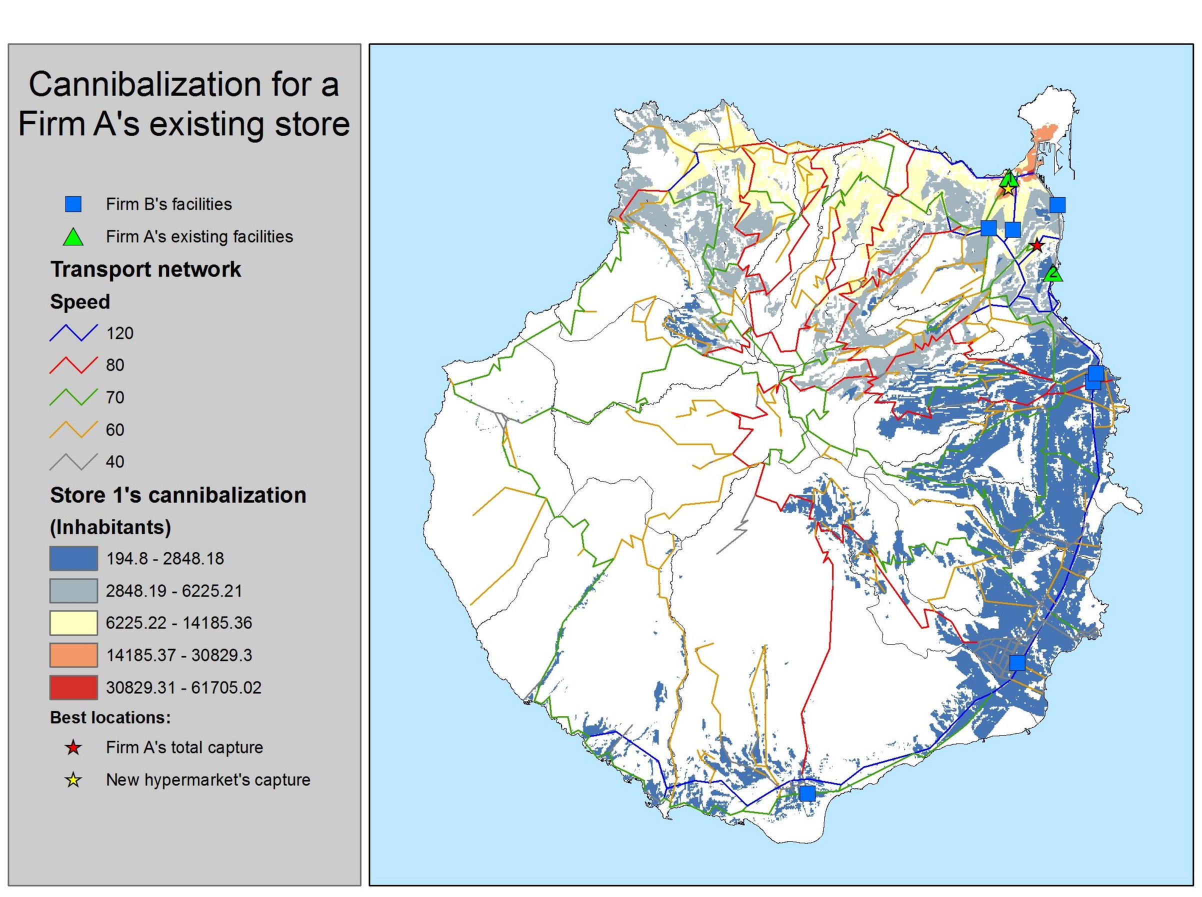
An additional ArcGIS-tool has been developed to summarize this information for each point in the feasible region.



New hypermarket market share: Capture obtained by the new store of Firm A considering both the existing and the new hypermarkets.

$$M(x_0)=\sum_{v_i\in V^d} w(v_i)\frac{\dfrac{a_0^\alpha}{c\left(x_0,v_i\right)^\lambda}}{\dfrac{a_0^\alpha}{c\left(x_0,v_i\right)^\lambda}+\displaystyle\sum_{v_j\in V^A\cup V^B}\dfrac{a_j^\alpha}{\left(c_{ij}\right)^\lambda}}.$$

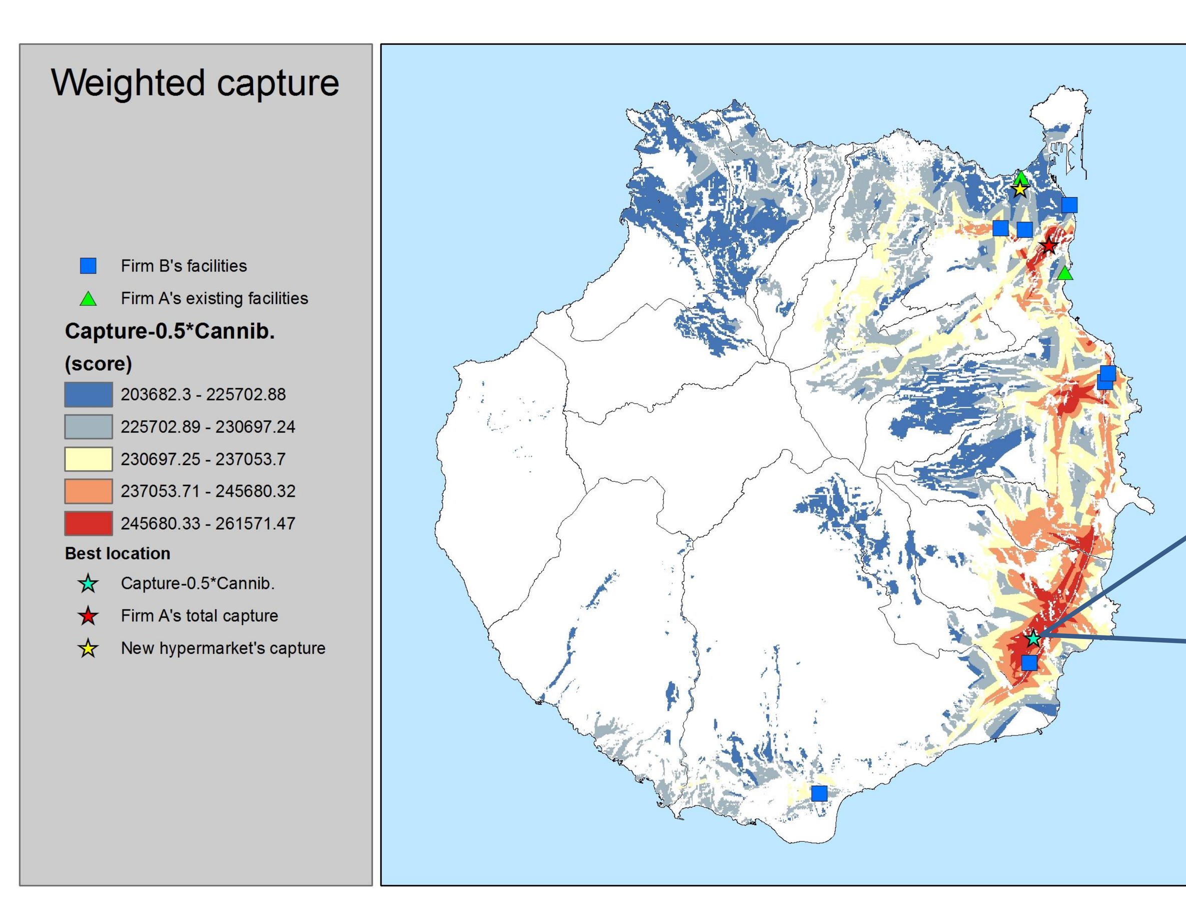
The location that maximize this function (the red star) is again in the capital, but in this case, it is very close to a facility belonging to the same firm.



Cannibalization for an existing facility (belonging to firm A): It represents the loss of market share produced at the facility by the entry of the new store.

$$C(v_j)=M(v_j)-\sum_{v_i\in V^d} w(v_i)\frac{\dfrac{a_j^\alpha}{\left(c_{ij}\right)^\lambda}}{\dfrac{a_0^\alpha}{c\left(x_0,v_i\right)^\lambda}+\displaystyle\sum_{v_k\in V^A\cup V^B}\dfrac{a_k^\alpha}{\left(c_{ik}\right)^\lambda}}.$$

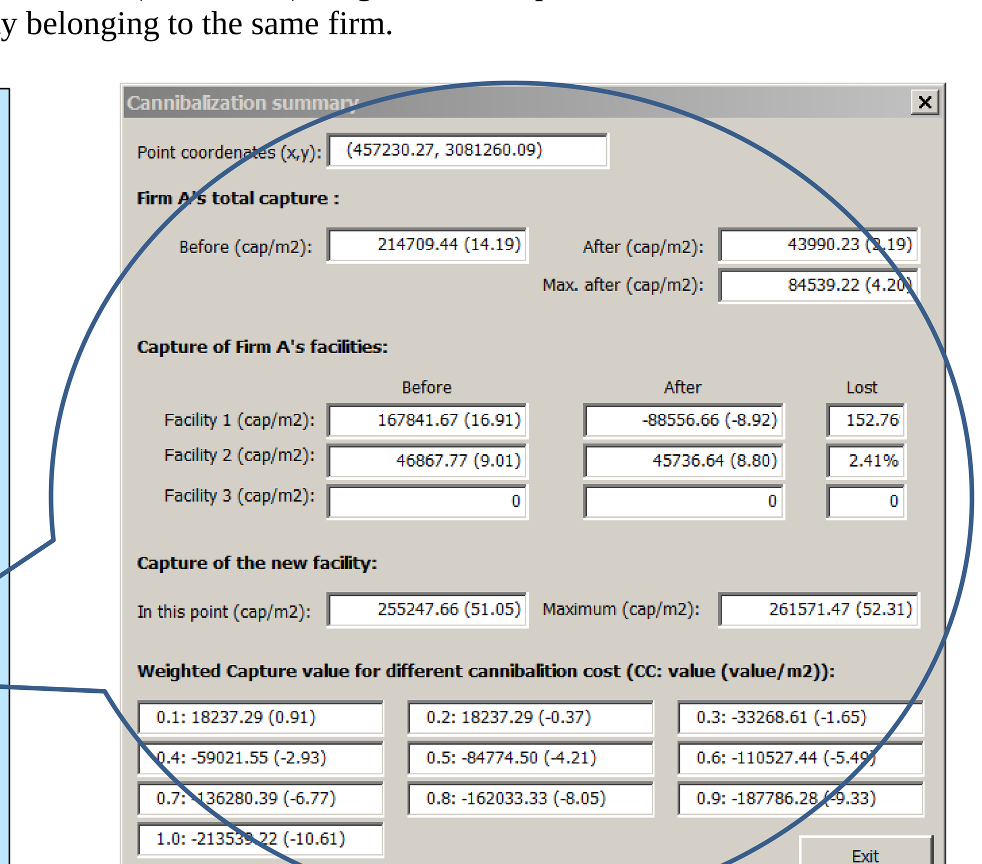
This map represents the cannibalization suffered by the northern existing. A similar map can be obtained for each firm A's existing facility.



Weighted capture: It represents the score for a location when a cannibalization cost is applied. The cannibalization cost value, c, must be chosen by the firm managers to reflect the firm's perception of the loss of market for its existing facilities.

$$WM(x_j)=M(x_j)-c\sum_{v_i\in V^A}C(v_i).$$

This map shows the weighted capture with cannibalization cost $c = 0.5$. The locations that maximize the different objectives (the total market share, the new firm market share, and the weighted capture) are also shown. A significant difference appears when the cannibalization costs is considered.



Clicking on a point of the feasible region, some information concerned to that location, before and after the location of the new facility, is reported,.

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