

# GIS Analyses and Maps Creation of a Naturalistic Area: The Carengione Oasis

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## Abstract

This paper describes the experience carried out with the aim to provide a technical and geo-referenced contribution to a project, submitted to the Common of Peschiera Borromeo in the Province of Milan in Lombardy. The promoter is a group of local associations; the aim is the valorisation and fruition of a green area, named Carengione Oasis. At first a GIS pre-analysis of the area has been performed to achieve a thorough knowledge of the area object of study. Then, a handheld GSP navigator has been employed to collect the data to be processed in a GIS software. This device choice has pros (a fast and very easy survey has been carried out) and cons (the acquired data have a precision of 3 to 5 meters). These data have been processed with the aid of the GIS software ArcMap release 10.4.1 by Esri. Also some free aerial images have been employed to edit features inaccessible on site. The achieved results are some thematic, metric and georeferenced maps and also a 3D virtual tour for a realistic visit of this area. They fulfil the project requirements. Anyway, due to their low precision, they have not been uploaded to enrich the official Lombardy cartography (DBTR); for this reason, part of them has been donated to the free data interchange OpenStreetMap. This work could be considered as a first step for future more precise surveys which would allow adding the acquired results to the DBTR; it has also been planned to create a story map describing the experience illustrated in this paper.

## Keywords

Carengione Oasis, Valorisation, Topographic Survey, GIS Analyses, Thematic, Geometric Georeferenced Maps, OpenStreetMap, 3D Virtual Tour

## 1. Introduction

The work described in this paper started with the purpose to provide a technical support, to a project promoted by some naturalistic associations. The aim is to

valorise and promote the fruition of a beautiful naturalistic area, named Carengione Oasis. This area is located in the Common of Peschiera Borromeo in the Province of Milan in northern Italy.

At first, it has been decided to research references to papers describing surveys of rural areas.

Literature shows that different survey techniques and instruments have been employed to perform this task, according to the job requirement, which anyway usually is land-use classification, plot boundaries assessment and precision agriculture.

They can range from total stations, static and RTK GPS receivers, drones and aerial or satellite images.

The first two instruments refer to an on the ground survey [1] [2] [3] which requires time and labour, but can provide more specific and more precise close-range landscape evaluations than the results derived from aerial (airborne and drone) [4] [5] and satellite images [6] [7] [8]. In some cases, combined technologies have been employed [9] [10].

Aerial and satellite images are available in web sites from which it is possible to download them for free. If a higher resolution is required, a new acquisition has to be planned from drone or airplane and also better satellite images can be acquired. Anyway, in these cases, costs obviously rise.

In the work presented here, public domain airborne images have been employed only as support for editing some inaccessible features on the ground; anyway, some naturalistic elements of interest, like rivers, paths and natural water sources, weren't identifiable in them, since hidden under the thick canopy of trees.

For this reason, on the ground survey methodology has been preferred.

Besides, with the aim to acquire data in easy and short time, and to allow some students carrying out the survey, a handheld GPS navigator has been chosen to perform the task. Of course the counterpart of this choice has been a lower degree of precision of the collected data and final results.

Anyway, it is known that handheld GPS navigators can record every movement when the GPS is turned on and it is possible to save current tracks and they are usually employed by hackers and other backcountry explorers. A 2019 ranking states that the market is dominated by one brand [11]. For this reason, and since it could fulfil the project requirements described in this paper, this kind of device was selected and employed.

In particular, literature reports only few articles describing similar applications of the same device selected here, but, in those cases, it was applied only for touring an area on foot [12], with the aim of random sampling rural populations, or for plot boundaries assessment [13].

The project was developed in three phases:

- a GPS navigator survey providing geo-referenced information about entrances, signs, boards, ponds, paths and areas of interest in the Oasis;
- a GIS pre-analysis to get a thorough knowledge of the area under investiga-

tion;

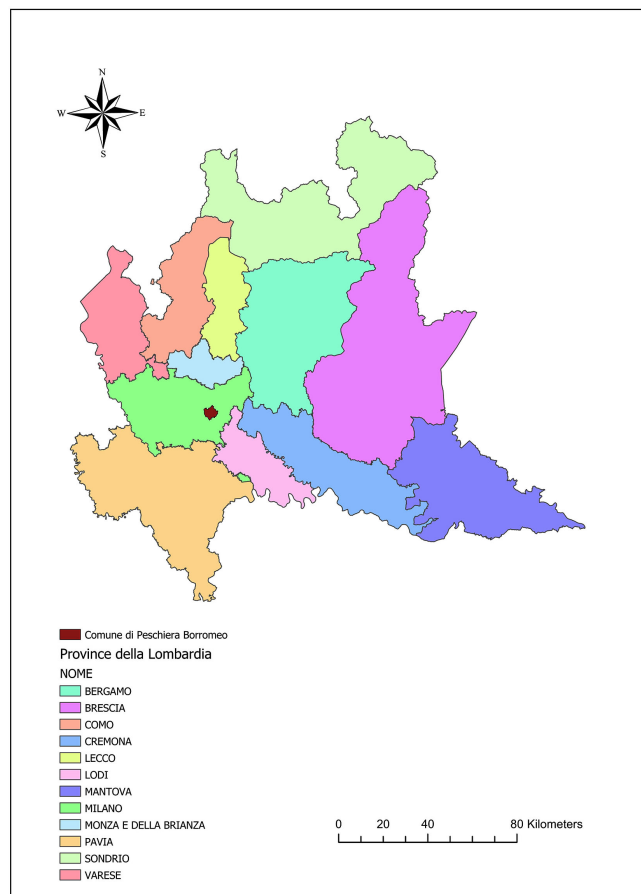
- a GIS post-analysis to provide georeferenced geometrical maps as technical support to the project.

This paper illustrates each step performed to achieve the results requested by the project.

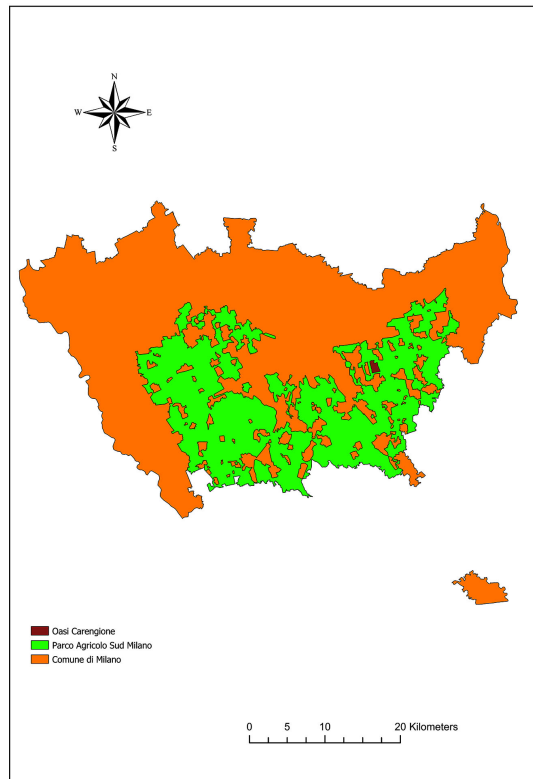
## 2. The Carengione Oasis

The Carengione is an area of naturalistic interest; it belongs to the Province of Milan, it is enclosed in the Parco Agricolo Sud Milano (PASM—South Milan Agricultural Park) [14] and it is placed in the common of Peschiera Borromeo [15] [Figure 1]. The place is beautiful and interesting from a naturalistic point of view and worth visiting; in the PASM website it is possible to look at some photos [16].

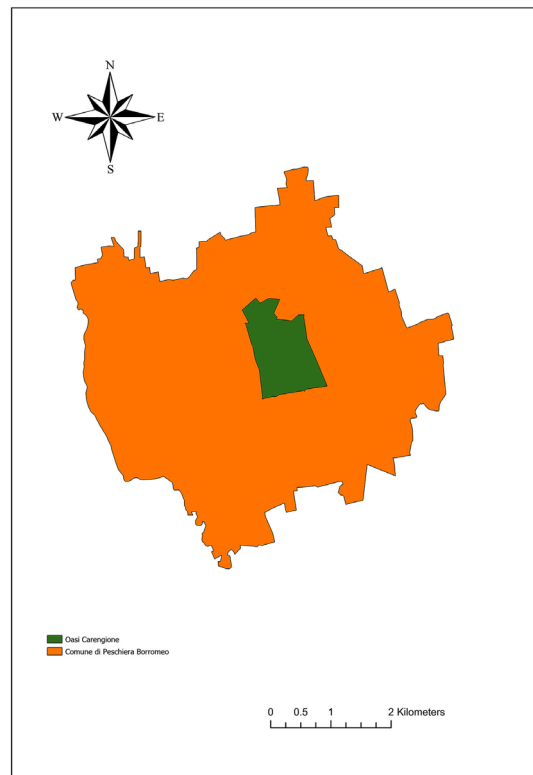
PASM [14] is placed in the metropolitan belt and it is managed by the metropolitan city of Milan [17]. It comprises the agricultural and forest areas of 61 commons, for a total extension of 47,000 Ha and it covers about the 30% of the total surface of the metropolitan city of Milan. It was born with the aim to protect and valorise the agricultural economy and to preserve the environment and the landscape.



(a)



(b)



(c)

**Figure 1.** The Common of Peschiera Borromeo in the province of Milan (a) and the Carengione Oasis in the PASM (b) and in the Common of Peschiera (c).

In particular, a natural oasis [18] is defined as a protected natural area with the aim to maintain the environmental equilibrium of a specific place, so as to keep a habitat of interest for the flora and fauna species. In fact, these places are dedicated to harbour and reproduction of the wild fauna and hunting is forbidden; for this reason, they are known as protection oasis.

The Carengione Oasis [19] [20] [21] [22] [23] is mostly occupied by irrigated crops and also by a spontaneous vegetation. Another peculiar character is due to the existing ponds which are related to the oscillating levels of the groundwater and which harbour many amphibians, like green frogs, tree frogs, emerald toads, crested newts and a variety of different fishes.

The Oasis, is one of the richest areas of biodiversity not only for the Common of Peschiera Borromeo, but also for the adjacent commons; a place where it is possible to find peace from the frenetic city life, where nature reigns unchallenged. The succession between open areas and tree-lined zones, the tranquillity and silence of this place make it a perfect location for many birds flying here in specific seasons of the year, such as wild geese, but also for animals like hares, badgers, hedgehogs and even foxes.

The Carengione, with its characteristics is a perfect place to host the nesting of a huge variety of butterflies and dragonflies. Lizards, green lizards, water snakes and bats also live here.

Also different species of trees can be found: white willows, alders, maples, hornbeams, hazel trees, elms, elders and hawthorns. A rich flora, with its beautiful colours, is growing undisturbed around the place. **Figure 2** shows some photos, provided by the naturalist Walter Ferrari, president of the Carengione naturalistic association [24], which demonstrate what has just been said.

The name origin could be explained according to two hypotheses: the first refers to the word cariggia, id est careggia, meaning roadway in the Milanese dialect, stemming from the furrows left by carts; in fact, inside the Oasis there is a local road named Strada Vicinale Mezzate-Fiorano. The second refers to the word cariggio or careggio, id est carice, meaning carex, which is a grass growing in marshes from which it is derived a material to cane chairs.

In 1956 works were started so as to transform the area in sand and gravel quarries, but this activity was abandoned for the poor quality of the extracted material; this depressed and hollow areas, created by these excavations, have been nowadays filled by groundwater and have become ponds.

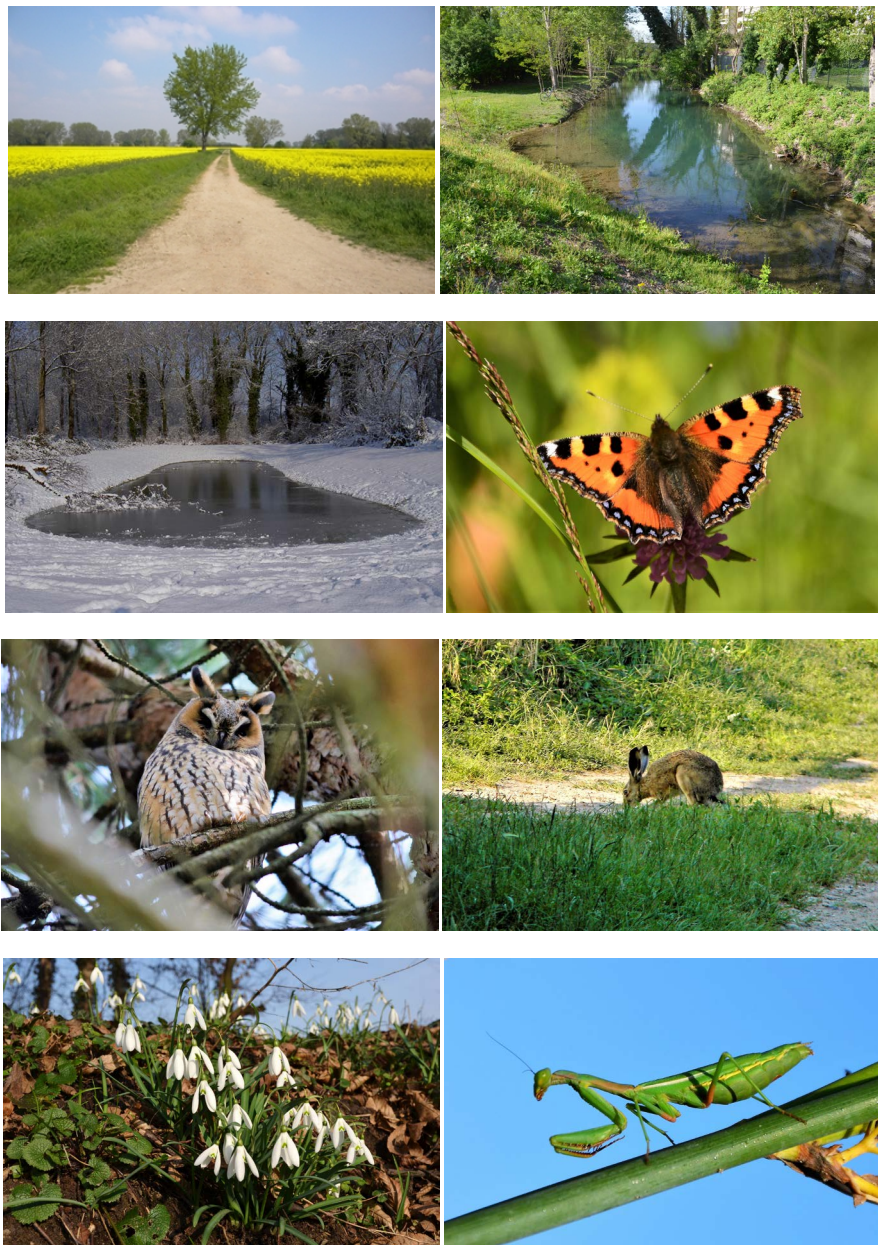
Only in the eighties the City Council of Peschiera Borromeo became interested in this land and in the nineties it became part of the just appointed PASM.

The Oasis is now shared by different owners: a woodland part of about 10 Ha belongs to the Province of Milan, where native plants have been planted from 2000 to 2005, another woodland part of about 2 Ha to the common of Peschiera Borromeo, which has been object of planting last year; the remaining part (the widest) belongs to private owners, and mostly devoted to croplands, as illustrated in **Figure 3**.

These data and shapefiles are part of the results achieved in this work and they will be explained further.

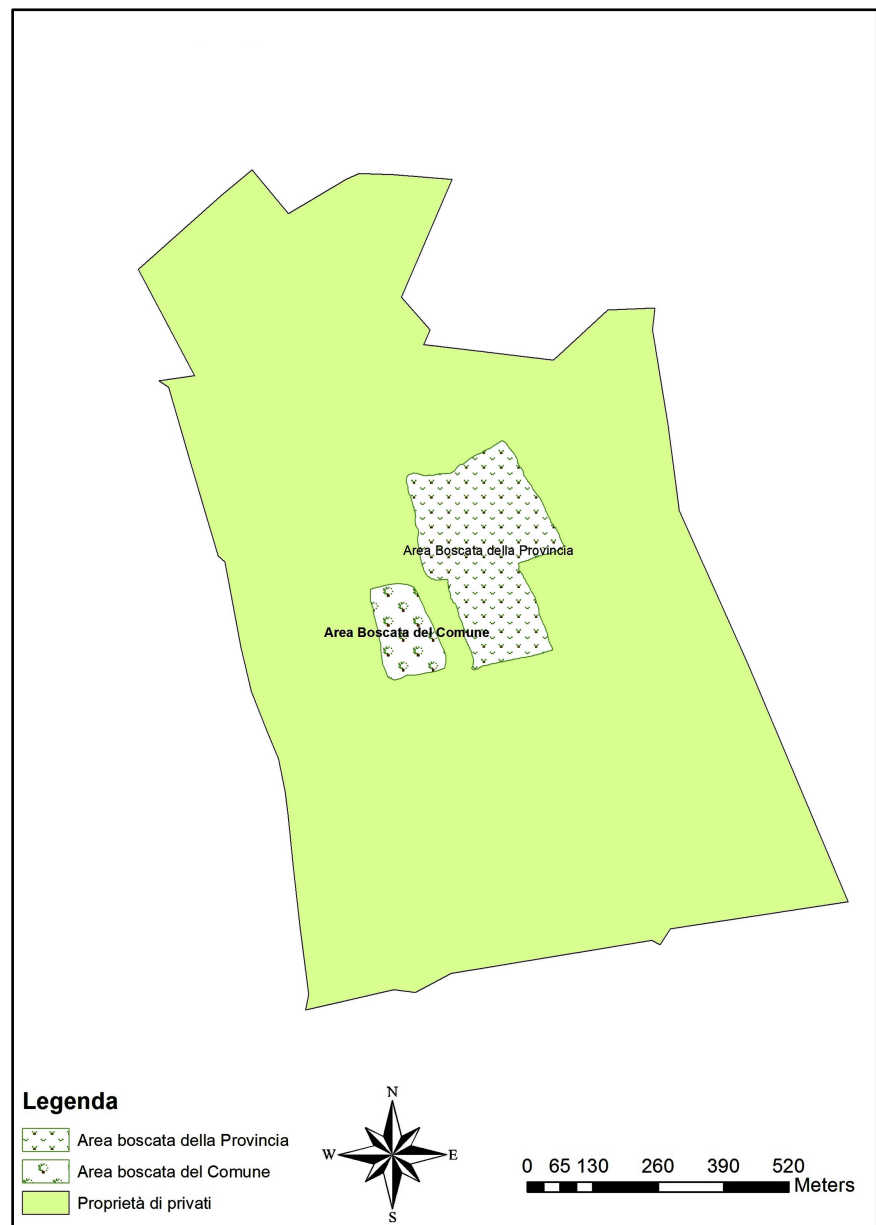
### 3. The “Enjoy Carengione” Project

The “Enjoy Carengione” project [25] has been financed by the common of Peschiera Borromeo as the winner of the 2018 participative budget, in the area concerning environment [26]. The project aims at the valorisation and better fruition of the wooded area of the Oasis and of the neighbouring green zones [27]. In fact, it is nearly placed in a barycentric position with respect to other parks and green public equipment areas.



**Figure 2.** Some beautiful pictures of the Carengione Oasis [24].





**Figure 3.** The properties shared in the Carengione Oasis by the Province of Milan, the Common of Peschiera Borromeo and the private owners.

“Enjoy Carengione” was born thanks to the contribution of volunteers from different associations, among which a naturalistic one [24], and the main purposed interventions are:

- production of a topographic map of the area;
- setting up of barriers at the entrances, if missing;
- restoration of a bridge over the Cavo Marocco which is a water course inside the Oasis;
- signs restoration;
- recovery of the path around a pond which is the widest of the 3 existing;
- creation of botanical routes thanks to the positioning of informative boards.

At the west entrance it has also been decided to build a little wooden house as info-point.

#### 4. Preliminary Instrumental Tests

The work presented here has started from what just said above, with the aim to provide some metric and georeferenced maps describing the place; this material will be then available for further studies and projects.

For this reason, the first step has been to perform a survey of the area; therefore, a Garmin Monterra GPS navigator [28] [29] has been employed, which receives GNSS signals, from GPS/GLONASS satellites and WAAS/EGNOS corrections [30] [31].

The instrument allows two different ways of performing a survey:

- waypoints: it is possible to acquire and record the 3D coordinates of a single point, which means its latitude, longitude and ellipsoidal height in the WGS84 reference system;
- routes: a path can be recorded as a sequence of points, in the WGS84 reference system, with a selectable step.

The acquired data are stored in \*.gpx files which can be easily exported with a point precision ( $\sigma_{\text{Garmin}}$ ) ranging from 3 to 5 m.

Since the project concerned the survey of only a rural area, it has been decided that a GPS navigator would easily accomplish this task, this way avoiding the use of a GNSS RTK receiver.

It has been decided to perform preliminary tests to verify the reliability of the instrument measures, before starting the Oasis survey.

The former takes into account a single vertex, carefully selected among the bench marks of the Italian GPS geodetic network, while the second examines an area, of nearly square shape, of appreciable extension, which means with sides of about 100 m.

They are illustrated hereafter.

**Test 1**—It has been selected a vertex of the IGM95 geodetic network [32] [33], placed in the common of Nembro in the Province of Bergamo, with an associated monography [34], as illustrated in **Figure 4**.

Selecting the waypoint acquisition, a set of measures has been acquired and later averaged so as to provide the most probable coordinates value (mean) of the vertex. These values have then been subtracted to the monography values and the residuals are illustrated in **Table 1**.

Since it is known that the instrument point precision ( $\sigma_{\text{Garmin}}$ ) can range from 3 to 5 m, it has been decided to accept these differences (residuals) if they fulfil the relationship:

$$\Delta_i < 1.96 * \sigma_{\text{Garmin}} (i = x, y, z) \quad (1)$$

This means that they respect this tolerance, defined by a significance level  $\alpha = 5\%$ . All the calculated differences verified this request and so they can be accepted as reliable results provided by the instrument.


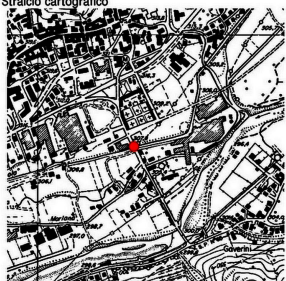

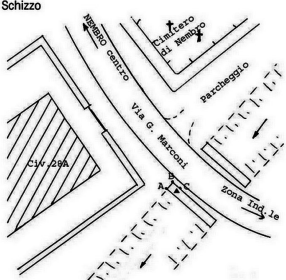


**Table 1.** The values analysis of the IGM GPS vertex.

	<i>X(m)</i>	<i>Y(m)</i>	<i>Z(m)</i>
<b>Averaged Coordinates</b>	4394622.303	756094.2685	4545480.5
<b>Monography Coordinates</b>	4394629.18	756095.81	4545484.41
<b>Residuals</b>	6.874717362	1.54606279	3.909077138



(a)

 <b>Regione Lombardia</b> Territorio e Urbanistica	Località: <b>NEMBRO (cimitero)</b>	Nome: <b>033626</b>	Sezione C.T.R. <b>C5c1</b>	Altri Enti:	
	<b>COMUNE DI NEMBRO</b>				
	Collegamento altimetrico da C.S. Quota=		Q. ell.: <b>H= 351,451</b>	Q.s.l.m.: <b>H= 305,145</b>	
	Rilievo effettuato da A.T.P. S.r.l. - Perugia - febbraio/giugno 2003				
<b>Accesso:</b> Da Nembro seguire le indicazioni per il cimitero; il punto si trova in via Marconi, di fronte al civico 28A, sul parapetto del ponte sulla roggia.					<b>Materializzazione:</b> Orientato infisso sulla sommità del muro in calcestruzzo con funzione di parapetto del ponte sulla roggia, a sud del cimitero di Nembro, in via Marconi di fronte al civico 28A, a Nembro.
<b>Stralzo cartografico</b> 			<b>Fotografia</b> 		
<b>Schizzo</b> 			<b>Coordinate geografiche (WGS84)</b> Lat.= 45°44'28,9647" Lon.= 09°45'43,7852"		
			<b>Coordinate geografiche (Roma40)</b> Lat.= 45°44'26,5319" Lon.= -2°41'23,5148"		
			<b>Coordinate piane (UTM-WGS84)</b> N= 5.065.596,026 E= 559.290,317		
			<b>Coordinate piane (GAUSS-BOAGA)</b> N= 5.065.616,577 E= 1.559.317,569		
			<b>Coordinate geografiche (ED50)</b> Lat.= 45°44'32,2734" Lon.= 09°45'47,5044"		
			<b>Coordinate piane (UTM-ED50)</b> N= 5.065.794,313 E= 559.372,479		

Collaudatori: Prof. Bezoari e Prof. Guzzetti del Politecnico di Milano - Verifica: IGM Firenze.

(b)

**Figure 4.** The IGM network vertex located in the Common of Nembro: the materialization on the ground (a) and its monography (b) [34].

**Test 2**—This test has been carried out selecting a sufficiently wide and regular area (almost a square) in the common of Alzano Lombardo in the Province of Bergamo, id est the Montecchio park [35]; the four vertexes have been identified and materialized with metallic stakes in the ground.

At first, with a steel ribbon, well tensed on the ground, the four sides of the area have been measured; by summing these values the perimeter was equal to  $2p = 368.9$  m.

Secondly, a Garmin routes acquisition of the sides has been realized, with a step of 0.5 m, providing a perimeter value  $2p = 369.7836$  m; the same acquisition, as waypoint every 8/10 steps, provided the value  $2p = 368.2552$  m.

The two Garmin values of the perimeter have then been subtracted to the ones collected with the steel ribbon; it has been decided to accept these values if they fulfil the relationship:

$$\Delta_{2p} < 1.96 * \sqrt{2} * \sqrt{n} * \sigma_{\text{Garmin}} \quad (2)$$

which means that they respect this tolerance defined by a significance level  $\alpha = 5\%$ .

The two differences are equal to 0.88 m (routes) and 0.64 (waypoint); in both cases the results respect the tolerance described above and so they confirm the instrument reliable measures.

Starting from the tests just described, it has been decided, for the Carengione survey, to perform a waypoint acquisition for the elements represented as points (boards, signs, entrances, etc.) and a routes acquisition for the paths, since this has showed to be a more practical and fast way to carry out on long distances.

## 5. A GIS Pre-Analysis of the Oasis Area

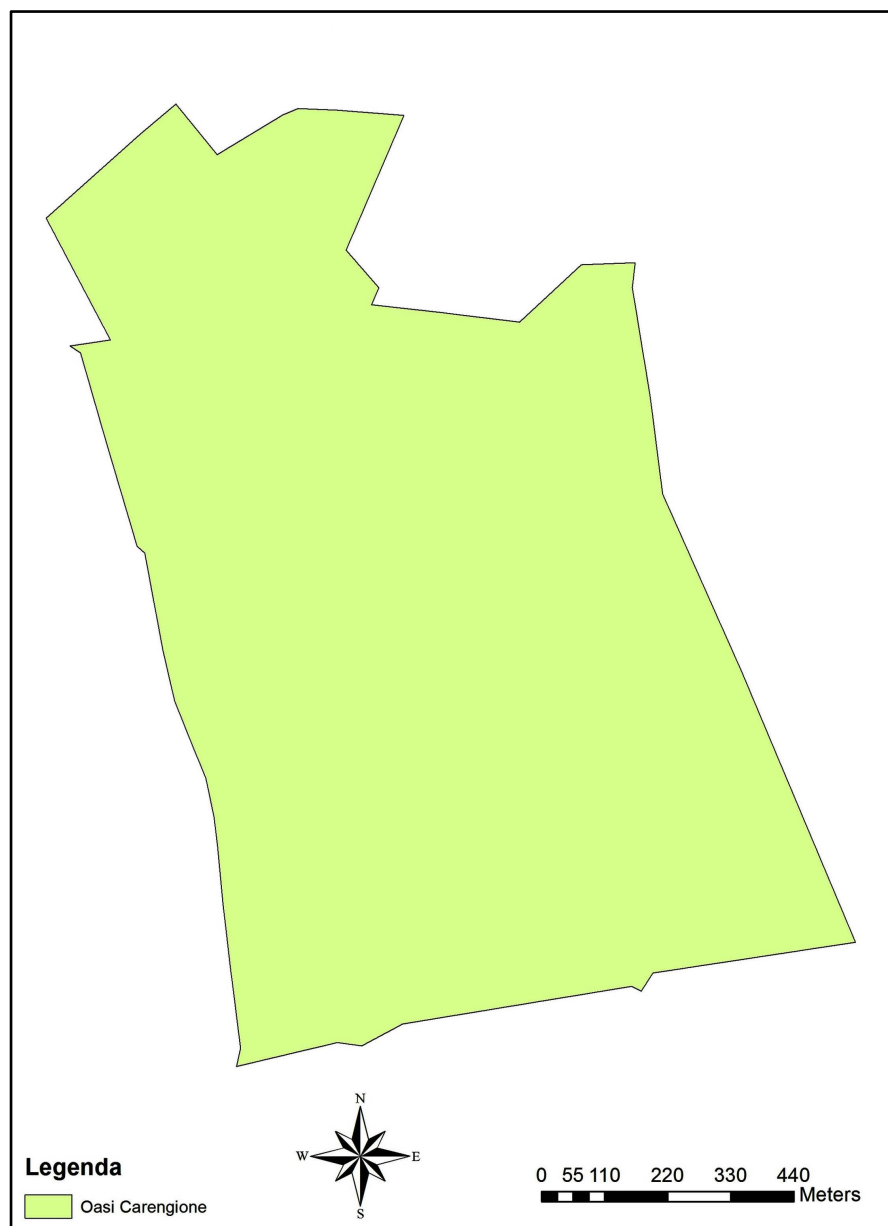
After performing the test step, it has been decided to achieve a thorough knowledge of the area object of study. It has been possible to find only one shapefile of the Carengione, in the WGS84 UTM Zone 32 reference system, which has been provided by the technical staff of the Common of Peschiera Borromeo [15], thanks to PASM [14]. This layer, loaded in Esri [36] ArcMap release 10.4.1, is illustrated in **Figure 5** and it provided the useful geometric information about the Oasis perimeter (5.64 km) and area (about 138 Ha).

Then, some analyses have been performed, in ArcGIS, on shapefiles downloaded from the Lombardy Geoportal [37] in the WGS84 UTM Zone 32N reference system.

For this reason, land-use has been investigated and the results have testified the changing in time, mostly due to human action. In fact, the ancient maps showed woods, in this area, till the second half of 1700; after the world war, the land has been devoted to rice farming and sowing of fodder and cereals as it is testified by an airborne survey performed in 1954 by GAI (Gruppo Aereo Italiano, id est Italian Aerial Group) [38], showing a land devoted to the cultivation of rice and arable crops (**Figure 6(a)**). On the other hand, from the 2012 DUSAF

4.0 (Destinazione d'Uso dei Suoli Agricoli e Forestali, id est Agriculture and Forest Soil Destination of Use) [39] shapefile it is possible to see, as illustrated in **Figure 6(b)**, that the area isn't devoted anymore only to culture: the rice fields have disappeared, the arable crops are still existing, but there are also new areas of woods and shrubs in different shades of green.

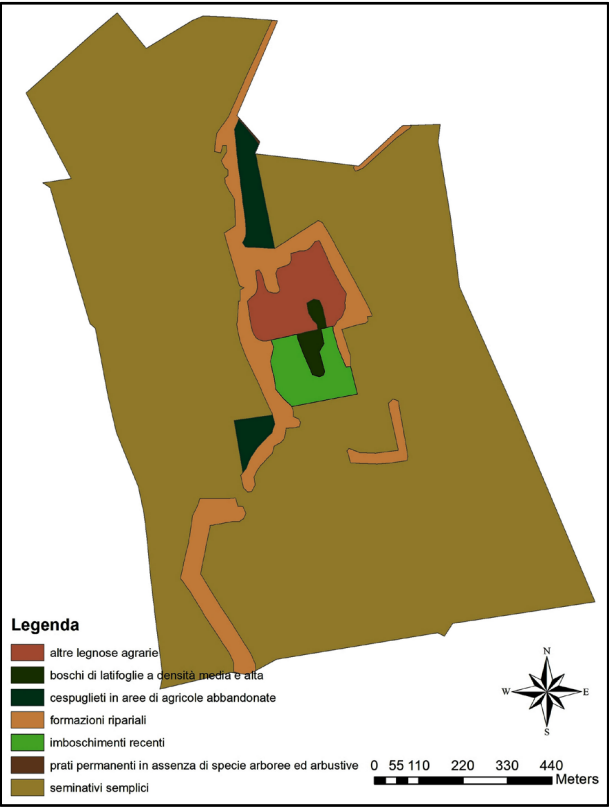
The Carengione is placed in the middle Padana Plain, between the High Plain at north and the Low Plain at south; the boundary between them is an area of natural water sources [40] [41]. Performing a soil granulometry and texture GIS analysis, it has been possible to see that the Oasis has a loamy and sand-clay soil composition (**Figure 7**).



**Figure 5.** The Carengione Oasis shapefile provided by the Common of Peschiera Borromeo through PASM.

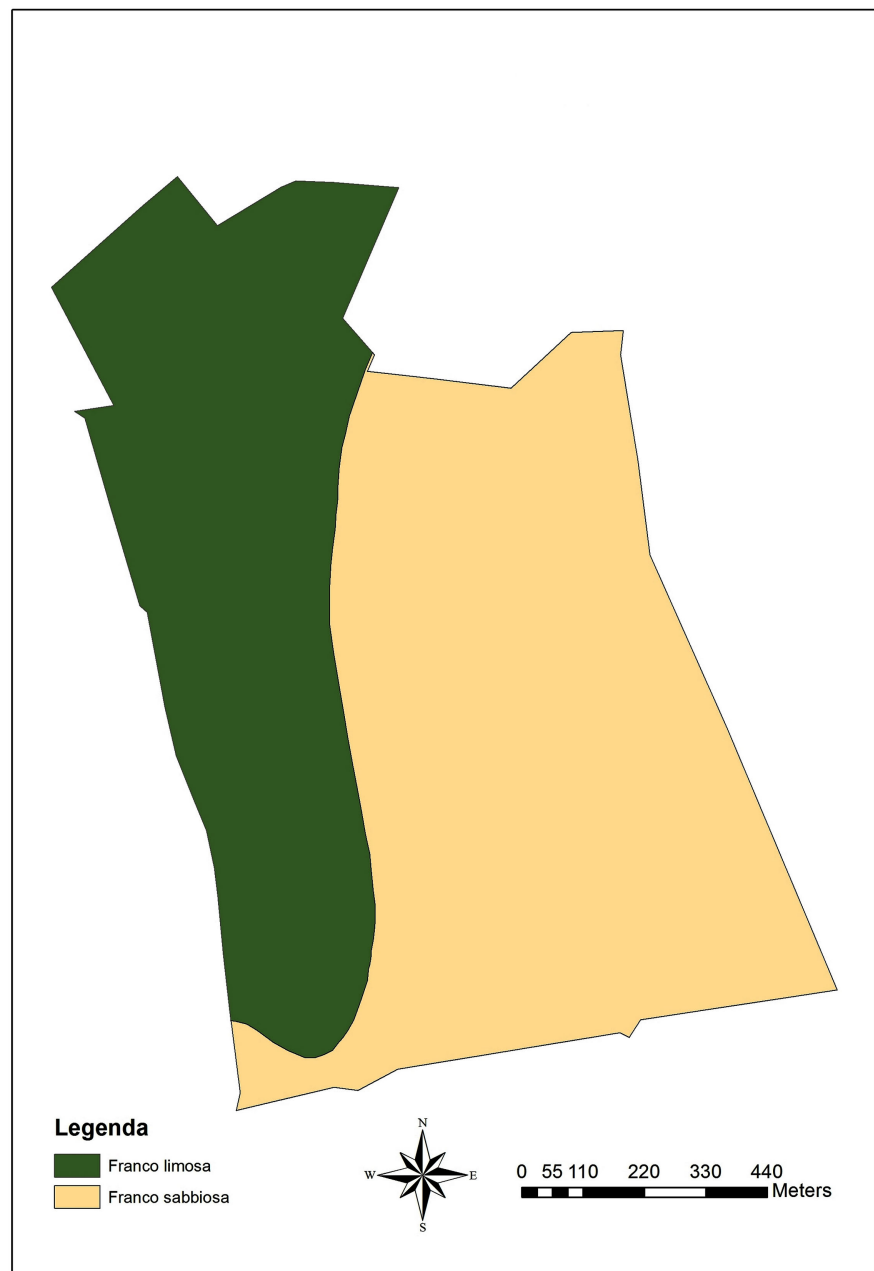


(a)



(b)

**Figure 6.** The land use change in the Carengione Oasis from 1954 (a) to 2012 (b).



**Figure 7.** The loamy (green) and sand-clay (beige) soil composition of the Oasis.

## 6. The on the Field Survey

This step has been performed in 4 days with the same acquisition techniques described before, which means waypoint for elements to be considered as points, while routes for the paths, and it provided some shapefile in the WGS84 UTM Zone 32N reference system.

This was possible, since the signal acquisition was always good, even inside the wooded areas.

- **Day 1**—It has been performed a waypoint recording of the 4 main entrances to the park. The same day, also the area dedicated to the info-point and the

Strada Vicinale Mezzate-Fiorano, a local road crossing the Carengione, were recorded in the routes way. They have then been imported in ArcMap providing their geometrical information, id est the perimeter and area of the info-point ( $2p = 21.3$  m and  $S = 20$  m<sup>2</sup>) and the length of the crossing road (1.37 km).

- **Day 2**—Some paths, devoted to the area tour, named and identified with the colors yellow, red, green, lilac and blue, have been recorded in the routes way. These data have then been loaded in ArcMap and their geometrical properties derived, which means their length. According to the just mentioned color order, they are 493 m, 229 m, 607 m, 389 m and 356 m.
- **Day 3**—The Oasis hosts two sources of water [40] [41], named Testa Vecchia and Testa Nuova, which are natural springs which have been resurfaced and are exploited by men; they were recorded as waypoints. Anyway, it is important to say that these springs are like little ponds, but it has been decided to choose only one single point to identify them, according to the procedure carried out by the Lombardy Region in a previous survey. In this survey the Region aimed to catalogue all the existing natural water sources in the region, identified with points chosen on the ground. Then, they have been imported in ArcMap and compared to the corresponding ones listed in the Geoportale shapefile [42] provided by the Lombardy region; it has been possible to see a good agreement for the position of the Testa Vecchia, but not for the Testa Nuova. This can easily be explained: in fact, it has not been possible to find a point on the ground marking the position of the previous survey performed by the Region techniques and for this reason, for this task, arbitrary points, close to the water sources, have been selected.

In this day, also the area and perimeter of the wooded zone belonging to the Province of Milan were recorded and also the position of informative signs (id est the regulation and ban of chasing signs and a bulletin board) inside the area, placed by the owner agency. All these data have then been imported in ArcMap and they allowed calculating this area which is about 8.36 Ha.

- **Day 4**—It has been recorded the Carengione outline, even if this information had been already provided by the shapefile from the Common of Peschiera and PASM. It has been quite difficult to perform this step, with a routes acquisition, since it has been challenging to identify on the ground a perfect outline enclosing the area; in fact, the acquired results show little differences from the already available ones, which means  $2p = 5.64$  km and  $S = 137.9$  Ha from the provided shapefile and  $2p = 5.56$  km and  $S = 136.27$  Ha as result of the survey. Anyway, they are quite close.

### The Editing Step

It is now important to say that it has not been possible to survey some elements directly on the field, such as the watercourses, the natural springs, the 3 existing ponds and the wooded area, property of the common of Peschiera Borromeo.

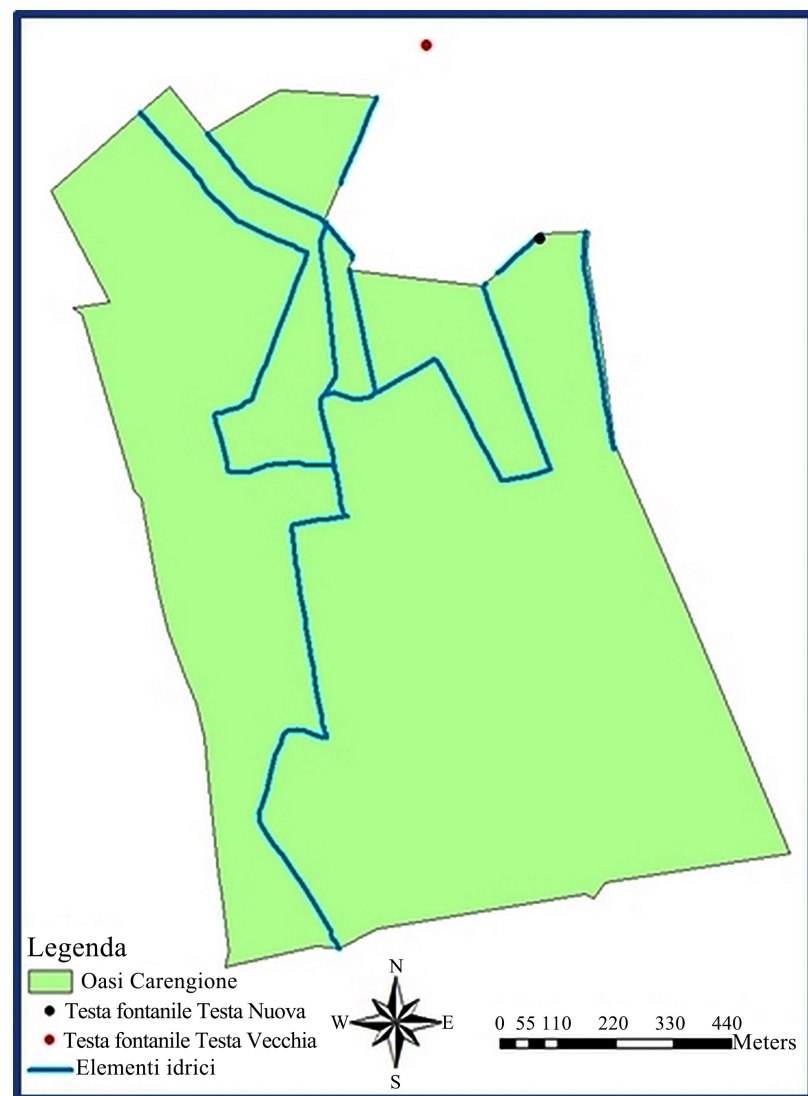


This is due to the limited accessibility, provided by the thriving, thick and wild vegetation, which didn't allow walking near these items on the ground. For this reason, this task has been accomplished in ArcMap with an editing session, performed over the Geoportal AGEA2015 Orthophoto [43], which provided the corresponding shapefiles properly georeferenced in the WGS84 UTM Zone 32N reference system.

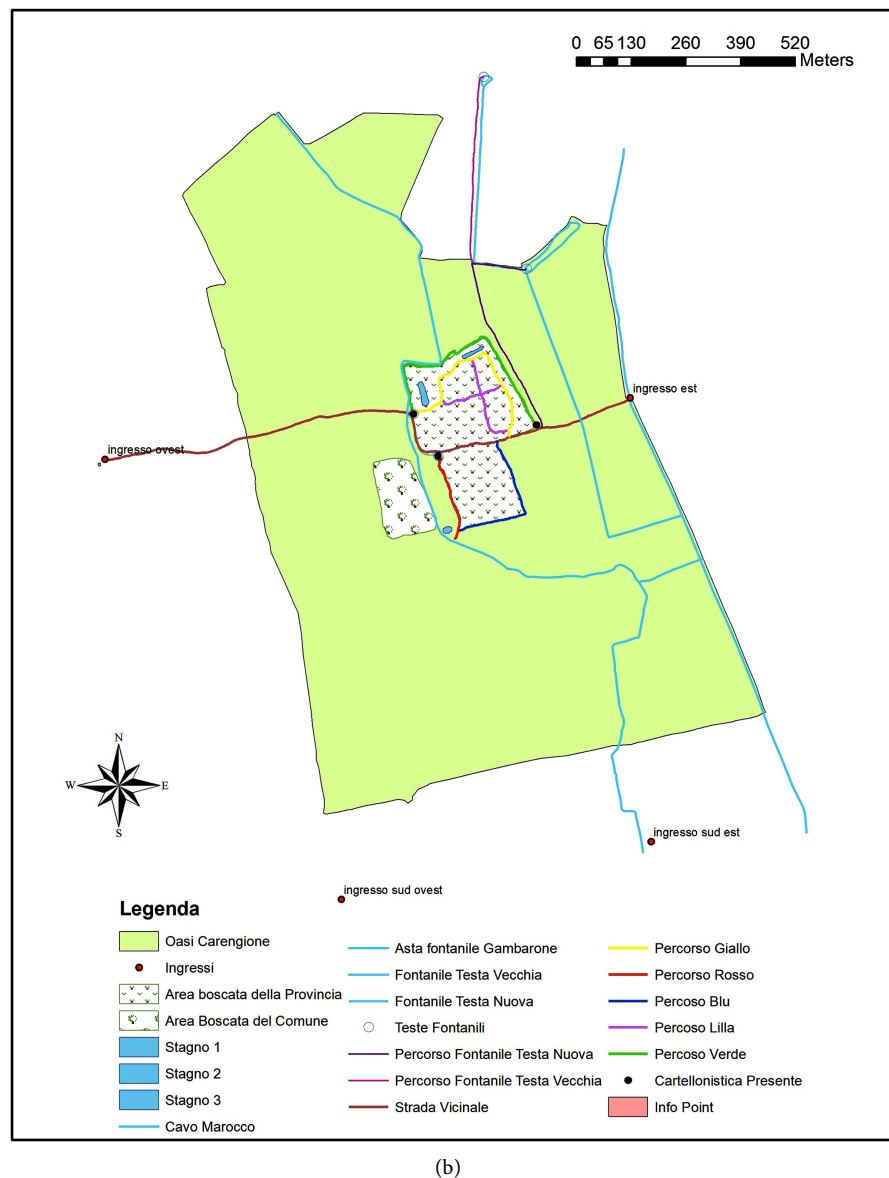
In particular, for the wooded area, it was possible to establish that its extension is of about 2 Ha.

## 7. Remarks on the Acquired Results

**Figure 8(a)** illustrates the only information originally available for the Oasis, which means the shapefiles of its area and perimeter, provided by PASM and the Common of Peschiera, and the natural water sources and watercourses downloaded from the Lombardy Geoportal.



(a)



**Figure 8.** The existing material on the (a) and the final acquired results on the (b).

**Figure 8(b)** illustrates the resulting product derived from the survey and editing steps which brought an effective enrichment of the information about the area, not only in a qualitative way, but also in a metric georeferenced one. This way, it has been provided a new map much different from the original one which was quite bare. In fact, the first map shows, as said, only the shape of the area, the two water sources and the water paths; instead, the second map shows, in addition, the two wooded areas, the four routes, the signs and entrances, the info point and the 3 ponds and the Strada Vicinale, crossing the area. In particular, it is obvious the difference among the water paths, in blue, in the two figures, but it can be easily explained, since they change their courses in time.

It is possible to state that, as a result of the steps illustrated above, now the Carengione Oasis is complemented by enriched shapefiles containing thematic

and geometric referenced information which can be easily visualized and managed in any GIS software.

In addition to the work developed till now, some suggestions have been made, so as to improve the bearing and travelling for visitors inside the Oasis, such as more signs at the entrances, for the paths travelling, and informative boards and signs. They will be evaluated and taken into account for further intervention.

## 8. Open Street Map

The achieved results have allowed fulfilling the project request of providing metric geo-referenced maps as support for any analysis of the Carengione Oasis.

Anyway, due to the low precision of the data acquired with the GPS navigator, which allowed point precisions from 3 to 5 m, it has not been possible to add the survey results to the official Lombardy cartography, which means the Regional Topographic Database (DBTR) [44]. For this reason, it has been decided to use them, or better donate them, to the collaborative and free project for collecting and distributing geographic data, in the WGS84 reference system, named OpenStreetMap [45]-[50]. It counts over 4 million users all over the world and its aim is to provide a world dynamic map, which means that everybody can contribute to enrich the information displayed in the map, by adding his own data (collected both with GPS devices and without GPS or through Apps for Android devices) and making them free and easily available to each user. This information is then released with an Open Data Commons Open Database (ODbL) license [51]. It is possible to download maps and save them in \*.osm files. These files can be easily managed, for instance, through the ArcGIS Editor for OpenStreetMap [52] which is a desktop toolset for ArcMap 10.5.x allowing loading data from OpenStreetMap and store them in a geodatabase. It is then possible to use the editing environment of ArcMap to create, modify, do network analysis, or update data. Once the editing is accomplished, it is possible to post back the edit changes to OSM to make them available to all the OSM users. These files can be also opened in QGIS [53], performing some simple steps. **Figure 9** illustrates, in OpenStreetMap, the Carengione Oasis before (a) and after (b) the uploading of the information collected during the experience described above; now it is free and accessible by everybody and it is possible to add new information and contribute to a better knowledge of the place.

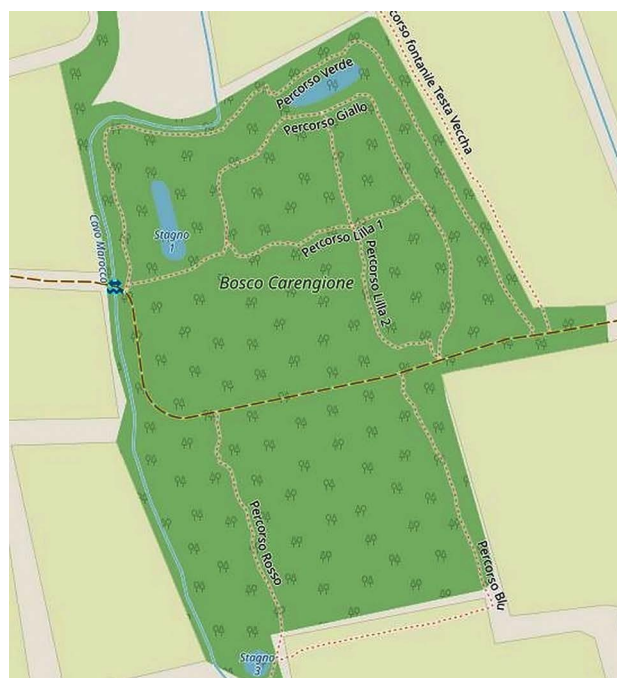
## 9. 3D Virtual Tour

So as to provide the feeling of walking through the Oasis, even to people staying everywhere, even comfortably seated at home, a 3D virtual tour has been recorded in ArcScene [54], which is an ArcGIS component. All the surveyed and edited files have been imported in ArcScene and then it has been possible to record a virtual tour while visiting the area. The result, archived in a \*.mp3 file, is quite effective and realistic and it allows living a nice natural and peaceful experience to everybody. In fact, also a sound background was added, recording

the wood sounds, which means mostly pleasant birds chirping. Some snapshots of the tour have been selected and are illustrated in **Figure 10**: they give an idea of the visitor moving toward the area and finally arriving at one pond. This is also quite a useful way to promote a better knowledge of a place where is really worth coming and which is certainly going to provide a peaceful, enriching and interesting experience.

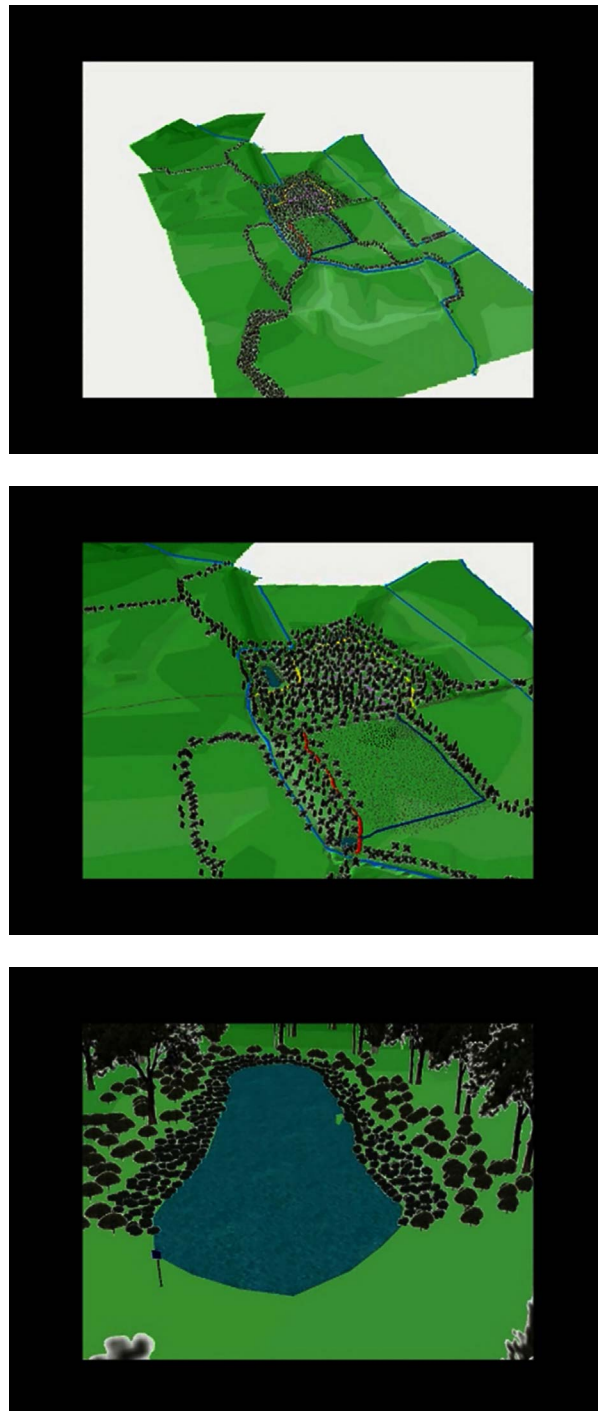


(a)



(b)

**Figure 9.** The Carengione Oasis in OpenStreetMap before (a) and after (b) the performed survey.



**Figure 10.** Three snapshots selected from the virtual tour.

## 10. Conclusion

At the beginning of this work, the area of the Carengione Oasis showed to be quite bare of geometric referenced information, but, after performing an on the filed survey and an editing step, the situation has definitively changed, showing a better reading of the zone, both from a qualitative and quantitative point of view. The achieved results have been donated to OpenStreetMap as contribution to a

collective free map service. Also a 3D virtual tour has been recorded simulating an on-site tour. The maps are now available as technical support for any work and analysis of the Carengione Oasis. Possible developments could be the employment of GNSS RTK receivers so as to provide shapefiles of higher precision, so as to correctly add them to the official Lombardy cartography (DBTR). Besides, in order to promote and advertise the Oasis to everybody everywhere, it has been planned to create a story map describing the experience illustrated in this paper and to share it with everybody. This will be accomplished thanks to Esri ArcGIS Story Map. This tool allows creating beautiful stories by bringing together text, maps, videos and photos and to easily publish and share them.

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## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

## References

- [1] Long, D.S., Degloria, S. and Galbraith, J. (1991) Use of the Global Positioning System in Soil Survey. *Journal of Soil & Water Conservation*, **46**, 293-297.
- [2] Kizil, U. and Tisor, L. (2011) Evaluation of RTK-GPS and Total Station for Applications in Land Surveying. *Journal of Earth System Science*, **120**, 215-221. <https://doi.org/10.1007/s12040-011-0044-y>
- [3] Jia, W.T., Liu, J.M., Yu, L.N., Yan, X.Y., Zhang, X.P., Jing, L.V., Zhao, Q.L. and Wang, M.H. (2007) Design and Implementation of a GPS-Based Field Survey System for Land Consolidation and Rehabilitation Projects. *New Zealand Journal of Agricultural Research*, **50**, 879-885. <https://doi.org/10.1080/00288230709510363>
- [4] Rao Mogili, U.M. and Deepak, B.B.V.L. (2018) Review on Application of Drone Systems in Precision Agriculture. *Procedia Computer Science*, **133**, 502-509. <https://doi.org/10.1016/j.procs.2018.07.063>
- [5] Salamí, E., Barrado, C. and Pastor, E. (2014) UAV Flight Experiments Applied to the Remote Sensing of Vegetated Areas. *Remote Sensing*, **6**, 11051-11081. <https://doi.org/10.3390/rs6111051>
- [6] Sharma, R.P., Singh, S.K., Singh R.S. and Arora S. (2018) Land Resource Inventory (LRI) for Development of Sustainable Agricultural Land Use Plans Using Geospatial Techniques: A Case Study of PataMeghpar Village, Jamnagar District, Gujarat. *Journal of Soil and Water Conservation*, **17**, 15-24. <https://doi.org/10.5958/2455-7145.2018.00003.6>
- [7] Varshney, K.R., Chen, G.H., Abelson, B., Nowocin, K., Sakhrani, V., Xu, L. and



- Spatocco, B.L. (2015) Targeting Villages for Rural Development Using Satellite Image Analysis. *Big Data*, **3**, 41-53. <https://doi.org/10.1089/big.2014.0061>
- [8] Doll, C.N.H. and Pachauri, S. (2010) Estimating Rural Populations without Access to Electricity in Developing Countries through Night-Time Light Satellite Imagery. *Energy Policy*, **38**, 5661-5670. <https://doi.org/10.1016/j.enpol.2010.05.014>
- [9] Rhodes, C.J., Henrys, P., Siriwardena, G.M., Whittingham, M.J. and Norton, L.R. (2015) The Relative Value of Field Survey and Remote Sensing for Biodiversity Assessment. *Methods in Ecology and Evolution*, **6**, 772-781. <https://doi.org/10.1111/2041-210X.12385>
- [10] Fuller, R.M., Groom, G.B., Mugisha, S., Ipule, P., Pomeroy, D., Katende, A., Bailey, R. and Ogutu-Ohwayo, R. (1998) The Integration of Field Survey and Remote Sensing for Biodiversity Assessment: A Case Study in the Tropical Forests and Wetlands of Sango Bay, Uganda. *Biological Conservation*, **86**, 379-391. [https://doi.org/10.1016/S0006-3207\(98\)00005-6](https://doi.org/10.1016/S0006-3207(98)00005-6)
- [11] <https://www.switchbacktravel.com/best-handheld-gps>
- [12] Kondo, M.C., Bream, K.D.W., Barg, F.K. and Branas, C.C. (2014) A Random Spatial Sampling Method in a Rural Developing Nation. *BMC Public Health*, **14**, 338. <https://doi.org/10.1186/1471-2458-14-338>
- [13] Odera, P.A. and Jatani, A.I. (2017) Assessment of Hand-Held GPS Surveying in Land Adjudication: A Case Study of Ngoliba Settlement Scheme in Kenya. *Journal of Agriculture, Science and Technology*, **18**, 24-37.
- [14] [http://www.cittametropolitana.mi.it/parco\\_agricolo\\_sud\\_milano](http://www.cittametropolitana.mi.it/parco_agricolo_sud_milano)
- [15] <https://www.comune.peschieraborromeo.mi.it/it>
- [16] [http://opencms.cittametropolitana.mi.it/parco\\_agricolo\\_sud\\_milano/natura/aree\\_naturalistiche/carengione.html#prettyPhoto](http://opencms.cittametropolitana.mi.it/parco_agricolo_sud_milano/natura/aree_naturalistiche/carengione.html#prettyPhoto)
- [17] <http://www.cittametropolitana.mi.it/portale>
- [18] [https://en.wikipedia.org/wiki/Nature\\_reserve](https://en.wikipedia.org/wiki/Nature_reserve)
- [19] <http://www.parcoagricolosudmilano.it/19-aree-naturalistiche-del-parco-agricolo-sud-milano/123-peschiera-borromeo-il-carengione.html>
- [20] Leondi, S. (2001) Il parco del Carengione. Passato, presente e futuro dell'oasi naturalistica di Peschiera Borromeo. Edited by the Comune di Peschiera Borromeo (Mi), April 2001, 32.
- [21] Ricotti, N. (2000) Parco Agricolo Sud Milano: flora e vegetazione del Carengione. Tesi presso l'Università degli Studi di Milano, Corso di Laurea in Scienze Naturali, Anno Accademico 1999/2000.
- [22] <https://www.aczivido.net/historia/lombardia/leondi3.html>
- [23] [http://www.cittametropolitana.mi.it/export/sites/default/parco\\_agricolo\\_sud\\_milano/pubblicazioni/.content/allegati/volumi/carengione.pdf](http://www.cittametropolitana.mi.it/export/sites/default/parco_agricolo_sud_milano/pubblicazioni/.content/allegati/volumi/carengione.pdf)
- [24] <http://www.associazioni.milano.it/carengione>
- [25] <https://it-it.facebook.com/EnjoyCarengione>
- [26] <https://www.7giorni.info/cronaca/peschiera-borromeo/peschiera-bilancio-partecipativo-trionfa-con-648-voti-il-progetto-per-la-riqualificazione-del-parco-carengione.html>
- [27] <https://www.7giorni.info/attualita/peschiera-borromeo/settore-ambiente-n.-8-enjoy-carengione---progetto-per-la-valorizzazione-e-fruizione-dell-area-boschiva-carengione-e-delle-aree-verdi-limitrofe.html>

- [28] <https://www.garmin.com/it-IT>
- [29] [http://www.tramsoft.ch/downloads/garmin/manuals/garmin\\_monterra/monterra\\_owners-manual\\_it.pdf](http://www.tramsoft.ch/downloads/garmin/manuals/garmin_monterra/monterra_owners-manual_it.pdf)
- [30] <https://vtecionosfera.wordpress.com/2012/02/08/i-sistemi-satellitari-di-navigazione-gps-glonass-galileo-capitolo-2-1>
- [31] <https://vtecionosfera.wordpress.com/2012/02/13/i-sistemi-satellitari-di-navigazione-i-sistemi-sbas-capitolo-2-9>
- [32] <https://www.igmi.org/it/descrizione-prodotti/elementi-geodetici-1/rete-igm95>
- [33] [http://www.geoportale.regione.lombardia.it/metadati?p\\_p\\_id=PublishedMetadata\\_WAR\\_geoportalemetadataportlet&p\\_p\\_lifecycle=0&p\\_p\\_state=maximized&p\\_p\\_mode=view&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_view=editPublishedMetadata&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_uuid=%7BB72433F5-7B35-479A-834E-9C999D95AF52%7D&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_editType=view&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_fromAsset=true&rid=local](http://www.geoportale.regione.lombardia.it/metadati?p_p_id=PublishedMetadata_WAR_geoportalemetadataportlet&p_p_lifecycle=0&p_p_state=maximized&p_p_mode=view&_PublishedMetadata_WAR_geoportalemetadataportlet_view=editPublishedMetadata&_PublishedMetadata_WAR_geoportalemetadataportlet_uuid=%7BB72433F5-7B35-479A-834E-9C999D95AF52%7D&_PublishedMetadata_WAR_geoportalemetadataportlet_editType=view&_PublishedMetadata_WAR_geoportalemetadataportlet_fromAsset=true&rid=local)
- [34] <http://www.cartografia.regione.lombardia.it/pdf/033626.pdf>
- [35] <http://www.comune.alzano.bg.it/citta/itinerari/itinerari-nei-centri-storici/il-parco-montecchio>
- [36] <http://www.esri.com>
- [37] <http://www.geoportale.regione.lombardia.it/>
- [38] [http://www.geoportale.regione.lombardia.it/metadati?p\\_p\\_id=PublishedMetadata\\_WAR\\_geoportalemetadataportlet&p\\_p\\_lifecycle=0&p\\_p\\_state=maximized&p\\_p\\_mode=view&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_view=editPublishedMetadata&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_uuid={13AF9B63-1943-47B7-AE27-55EF9E8C8638}&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_editType=view&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_fromAsset=true&rid=local](http://www.geoportale.regione.lombardia.it/metadati?p_p_id=PublishedMetadata_WAR_geoportalemetadataportlet&p_p_lifecycle=0&p_p_state=maximized&p_p_mode=view&_PublishedMetadata_WAR_geoportalemetadataportlet_view=editPublishedMetadata&_PublishedMetadata_WAR_geoportalemetadataportlet_uuid={13AF9B63-1943-47B7-AE27-55EF9E8C8638}&_PublishedMetadata_WAR_geoportalemetadataportlet_editType=view&_PublishedMetadata_WAR_geoportalemetadataportlet_fromAsset=true&rid=local)
- [39] [http://www.geoportale.regione.lombardia.it/metadati?p\\_p\\_id=PublishedMetadata\\_WAR\\_geoportalemetadataportlet&p\\_p\\_lifecycle=0&p\\_p\\_state=maximized&p\\_p\\_mode=view&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_view=editPublishedMetadata&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_uuid={D4734F9B-3728-4B97-B07D-2C4060EBC862}&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_editType=view&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_fromAsset=true&rid=local](http://www.geoportale.regione.lombardia.it/metadati?p_p_id=PublishedMetadata_WAR_geoportalemetadataportlet&p_p_lifecycle=0&p_p_state=maximized&p_p_mode=view&_PublishedMetadata_WAR_geoportalemetadataportlet_view=editPublishedMetadata&_PublishedMetadata_WAR_geoportalemetadataportlet_uuid={D4734F9B-3728-4B97-B07D-2C4060EBC862}&_PublishedMetadata_WAR_geoportalemetadataportlet_editType=view&_PublishedMetadata_WAR_geoportalemetadataportlet_fromAsset=true&rid=local)
- [40] <https://www.comune.peschierabormero.mi.it/it/page/i-fontanili>
- [41] <https://www.parcoaddasud.it/portale/images/Progetti/Fontanili/guida.pdf>
- [42] [http://www.geoportale.regione.lombardia.it/metadati?p\\_p\\_id=PublishedMetadata\\_WAR\\_geoportalemetadataportlet&p\\_p\\_lifecycle=0&p\\_p\\_state=maximized&p\\_p\\_mode=view&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_view=editPublishedMetadata&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_uuid={28A86DEA-5E1E-4D4C-9FC6-DCFD2A3219E6}&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_editType=view&\\_PublishedMetadata\\_WAR\\_geoportalemetadataportlet\\_fromAsset=true&rid=local](http://www.geoportale.regione.lombardia.it/metadati?p_p_id=PublishedMetadata_WAR_geoportalemetadataportlet&p_p_lifecycle=0&p_p_state=maximized&p_p_mode=view&_PublishedMetadata_WAR_geoportalemetadataportlet_view=editPublishedMetadata&_PublishedMetadata_WAR_geoportalemetadataportlet_uuid={28A86DEA-5E1E-4D4C-9FC6-DCFD2A3219E6}&_PublishedMetadata_WAR_geoportalemetadataportlet_editType=view&_PublishedMetadata_WAR_geoportalemetadataportlet_fromAsset=true&rid=local)
- [43] <https://www.agea.gov.it/portal/page/portal/AGEAPageGroup/HomeAGEA/ChiSiamo>
- [44] <https://www.regione.lombardia.it/wps/portal/istituzionale/HP/DettaglioServizio/servizi-e-informazioni/Enti-e-Operatori/Territorio/sistema-informativo-territoriale-sit/database-topografico-regionale>

- [45] <https://www.openstreetmap.org/>
- [46] <https://learnosm.org/en/beginner/introduction/>
- [47] <http://ilmegliodiinternet.it/openstreetmap-la-mappa-libera-wikipedia-like>
- [48] <https://stackshare.io/stackups/google-maps-vs-openstreetmap>
- [49] <http://www.missingmaps.org>
- [50] [https://wiki.openstreetmap.org/wiki/IT:Visibility\\_of\\_GPS\\_traces](https://wiki.openstreetmap.org/wiki/IT:Visibility_of_GPS_traces)
- [51] <https://opendatacommons.org/licenses/odbl/>
- [52] <https://www.arcgis.com/home/item.html?id=4533407decd94428817a228cb36964cf>
- [53] <https://www.qgis.org/it/site>
- [54] <http://desktop.arcgis.com/en/arcmap/10.3/main/get-started/choosing-the-3d-display-environment.htm>