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Optimization of waste transportation costs in Mtskheta-Mtianeti region

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Abstarct:
According to the given plan, the garbage trucks of Mtskheta municipality will run out of time everywhere except Mtskheta. Regarding the current situation in Mtskheta, there are not enough garbage trucks, because emptying 159 bins every day, when it takes four minutes to empty one bin, the working time is 10:36 hours, 63:36 minutes per week, which is against the requirements of the Labor Code.
In conclusion, I would like to note that modern computer technologies have many opportunities for solving various optimization tasks. It is important that these technologies are implemented in both private and state structures. This will allow us to optimally use the budget funds and direct the freed funds to solve other social and economic problems of the region.
Key points: region, municipalities, unpressed garbage, geovision

Introduction

I chose Mtskheta-Mtianeti to solve the task of optimizing waste transportation costs. There were various reasons for this: there are many enterprises in Mtskheta, distinguished in terms of tourism in all seasons, Mtskheta is one of the leading cities, which are divided into administrative units and villages.

I contacted Mtskheta City Hall for the process of solving the optimization task regarding waste management in Mtskheta-Mtianeti. On the basis of a preliminary application, I was sent electronically the factual data related to this topic, based on which I can formulate problems related to the mentioned issue:

- Lack of waste containers, which is why the waste collection service is provided to the population from 22 administrative units included in the municipality from Mtskheta and only 50 out of 62 villages. 12 villages remain without services. These villages are: Buriani, Chilaantkari, Mshralkhevi, Khekordzi, Satovle, Karsani, Bevreti, Tabaruki, Lelobi, Dzalaantkhevi, Agaraki, Nakhshirgora.
- The waste management standardization system for the region should be improved. There is no national standard in the field of waste management in Georgia. Municipalities do not have instructions, technical norms, if implemented and introduced, it will be possible to solve the problems of waste management. As stated in the 2023-2027 municipal waste management plan on the territory of Mtskheta municipality, there is low awareness of working staff, what approaches exist in the field of waste management in European countries.
- There is no street clearing in the villages included in the municipality. There are many irregular landfills in the villages, mainly rivers and gorges. The municipality does not record

waste by species or characteristics. Waste is not separated at the collection stage, composting practices are not implemented.

On the first of April 2016, the Resolution of the Government of Georgia N159 of the adopted regulation, which refers to "Municipal waste collection and processing rules".

Article 12 refers to municipal waste flows, where it is mentioned that

When making a decision related to service optimization, the municipality must obtain and use the following information:

a) population size;

b) Determination of the average amount of waste generated per capita in the service area, thereby determining the daily amount of waste to be collected;

c) the size and volume of loading possible in the waste collection vehicle;

d) It is necessary to determine the optimal collection route (Route), which in some cases coincides with administrative or geographical boundaries.

The optimal route will allow us to reduce the service time, determine the number of garbage trucks stopping and containers. I used the Geovision program to optimize the route of garbage trucks, it has been on the market since 2005 and ensures that their customers can plan a reasonable route and live tracking of vehicles.

This program helps us in personalized and optimal route planning based on the peculiarities of different business models.

NNLE Mtskheta Municipality Improvement Service does not have waste transportation drawings and maps. In the future, the municipality plans to develop a map showing the rational routes of waste transportation.

As mentioned in the technical regulation, in order to achieve the development of waste collection and transportation systems and optimization of services, it is necessary to determine the right routes. Division of the area covered by services into zones (village) depending on which area will be served by which vehicle.

To solve the optimization task, I first collected information about Mtskheta and its villages. Population, amount of waste, number of bins, number of waste collection vehicles and data in Mtskheta municipality.

The local government of Mtskheta municipality is responsible for the management of flexible waste in the territory, more specifically, Mtskheta City Hall is responsible for the collection and transportation of municipal waste, cleaning of streets, squares, parks and other public places.

The collection and removal of waste generated in the territory of Mtskheta municipality to the solid household waste landfill of the municipality is ensured by the improvement service of NNLE Mtskheta municipality.

The waste collected in Mtskheta municipality is transferred to Kaspi, Akhtala area, 6 km from the village of Mikeltskaro, to the landfill.

City of Mtskheta Improvement Service has a waste collector, garbage trucks equipped with a press. 10 units in total.

Type of vehicle	Quantity	Capacity (m3)	Tones
Mercedes-benz	1	7	3.5
Mercedes-benz	1	7	3.5
Mercedes-benz	1	7	3.5
Mercedes-benz	1	13	6.5
Mercedes-benz	1	13	6.5

Mercedes-benz	1	13	6.5
Ford	1	13	6.5
Ford Kargo	1	13	6.5
Ford	1	13	6.5
Ford Kargo	1	18	9

There is pressed and unpressed waste. 1kb.M weighs about 500 kg of pressed garbage, 150 kg of unpressed garbage. Since these cars press garbage, to convert the numbers given in cubic meters into tons, I multiplied them by 0.5, so we got that Mtskheta municipality has 3 Mercedes Benz brand 3.5 ton garbage trucks, 3 Mercedes Benz brand 6.5 ton ones, 3 Ford brand 6.5 ton ones, 1 piece 9 ton Ford Kargo brand garbage truck.

To calculate routines in the Geovision program, you need to perform calculations:

			Method 1				Method 2						
Region	Population	numbers of bins	Rate	Year	Day	Day-Can	Rate	Year	Day	Day-Can	MAX	day	DAY
Mskhaldidi	776	23	0.01966	242.166	0.66347	0.02885	0.01709	210.534	0.57681	0.02508	0.02885	5.19994	5
Dzalisi	2281	68	0.05777	711.832	1.95022	0.02868	0.05052	622.45	1.70534	0.02508	0.02868	5.23017	5
Mukhrani	6422	190	0.16266	2004.11	5.49072	0.0289	0.14116	1739.2	4.76492	0.02508	0.0289	5.19057	5
Arashenda	209	7	0.00529	65.2227	0.17869	0.02553	0.0052	64.0757	0.17555	0.02508	0.02553	5.87603	5
Ereda	630	18	0.01596	196.604	0.53864	0.02992	0.01337	164.766	0.45141	0.02508	0.02992	5.01261	5
New Nichbisi	624	18	0.01581	194.732	0.53351	0.02964	0.01337	164.766	0.45141	0.02508	0.02964	5.06081	5
Tsilkani	2842	90	0.07198	886.903	2.42987	0.027	0.06686	823.83	2.25707	0.02508	0.027	5.55585	5
Dzegvi	2822	85	0.07148	880.662	2.41277	0.02839	0.06315	778.062	2.13168	0.02508	0.02839	5.28438	5
Zemo Nichbisi	270	8	0.00684	84.2589	0.23085	0.02886	0.00594	73.2294	0.20063	0.02508	0.02886	5.19826	5
Saskhori	356	11	0.00902	111.097	0.30438	0.02767	0.00817	100.69	0.27586	0.02508	0.02767	5.42094	5
Akhalsofeli	165	5	0.00418	51.4916	0.14107	0.02821	0.00371	45.7684	0.12539	0.02508	0.02821	5.3164	5
Navazi	656	19	0.01662	204.718	0.56087	0.02952	0.01412	173.92	0.47649	0.02508	0.02952	5.08138	5
Lisi	597	20	0.01512	186.306	0.51043	0.02552	0.01486	183.073	0.50157	0.02508	0.02552	5.87743	5
Small Kanda	461	15	0.01168	143.864	0.39415	0.02628	0.01114	137.305	0.37618	0.02508	0.02628	5.7085	5
Qvemo Nichbisi	565	18	0.01431	176.32	0.48307	0.02684	0.01337	164.766	0.45141	0.02508	0.02684	5.58928	5
Zaqaro	631	19	0.01598	196.916	0.5395	0.02839	0.01412	173.92	0.47649	0.02508	0.02839	5.2827	5
Chardakhi	663	19	0.01679	206.902	0.56686	0.02983	0.01412	173.92	0.47649	0.02508	0.02983	5.02773	5
Tserovani	2011	58	0.05094	627.573	1.71938	0.02964	0.04309	530.913	1.45456	0.02508	0.02964	5.05997	5
Tsinamdzgvriantkari	426	14	0.01079	132.942	0.36422	0.02602	0.0104	128.151	0.3511	0.02508	0.02602	5.76568	5
Gorovani	394	15	0.00998	122.956	0.33686	0.02246	0.01114	137.305	0.37618	0.02508	0.02508	5.98121	5
Frezeti	66	4	0.00167	20.5966	0.05643	0.01411	0.00297	36.6147	0.10031	0.02508	0.02508	5.98121	5
Ufureti	29	2	0.00073	9.05003	0.02479	0.0124	0.00149	18.3073	0.05016	0.02508	0.02508	5.98121	5
Akhaldaba	56	4	0.00142	17.4759	0.04788	0.01197	0.00297	36.6147	0.10031	0.02508	0.02508	5.98121	5
Shankevani	93	4	0.00236	29.0225	0.07951	0.01988	0.00297	36.6147	0.10031	0.02508	0.02508	5.98121	5
Mshralkhevi	15	2	0.00038	4.68105	0.01282	0.00641	0.00149	18.3073	0.05016	0.02508	0.02508	5.98121	5
Khekordzi	12	4	0.0003	3.74484	0.01026	0.00256	0.00297	36.6147	0.10031	0.02508	0.02508	5.98121	5
Akhalubani	454	15	0.0115	141.68	0.38816	0.02588	0.01114	137.305	0.37618	0.02508	0.02588	5.79652	5
Navdaraantkari	345	15	0.00874	107.664	0.29497	0.01966	0.01114	137.305	0.37618	0.02508	0.02508	5.98121	5
Ksani	1291	40	0.0327	402.883	1.10379	0.02759	0.02972	366.147	1.00314	0.02508	0.02759	5.43583	5
Tsikhisdziri	1810	63	0.04584	564.847	1.54753	0.02456	0.04681	576.681	1.57995	0.02508	0.02508	5.98121	5

Ksani	1291	40	0.0327	402.88	1.1038	0.0276	0.0297	366.15	1.0031	0.0251	0.0276	5.4358	5
Tsikhisdziri	1810	63	0.0458	564.85	1.5475	0.0246	0.0468	576.68	1.5799	0.0251	0.0251	5.9812	5
Ksovrisi	1380	45	0.035	430.66	1.1799	0.0262	0.0334	411.92	1.1285	0.0251	0.0262	5.7209	5
Vardisubani	167	10	0.0042	52.116	0.1428	0.0143	0.0074	91.537	0.2508	0.0251	0.0251	5.9812	5
Vaziani	612	20	0.0155	190.99	0.5233	0.0262	0.0149	183.07	0.5016	0.0251	0.0262	5.7334	5
Misakcieli	2107	65	0.0534	657.53	1.8015	0.0277	0.0483	594.99	1.6301	0.0251	0.0277	5.4123	5
Aghdgomliantkari	371	18	0.0094	115.78	0.3172	0.0176	0.0134	164.77	0.4514	0.0251	0.0251	5.9812	5
Saguramo	1578	62	0.04	492.45	1.3492	0.0218	0.0461	567.53	1.5549	0.0251	0.0251	5.9812	5
Tsitsamuri	122	6	0.0031	38.073	0.1043	0.0174	0.0045	54.922	0.1505	0.0251	0.0251	5.9812	5
Galavani	468	20	0.0119	146.05	0.4001	0.02	0.0149	183.07	0.5016	0.0251	0.0251	5.9812	5
Tskhvaritchamia	143	17	0.0036	44.626	0.1223	0.0072	0.0126	155.61	0.4263	0.0251	0.0251	5.9812	5
Lelubani	58	3	0.0015	18.1	0.0496	0.0165	0.0022	27.461	0.0752	0.0251	0.0251	5.9812	5
Mamkoda	47	3	0.0012	14.667	0.0402	0.0134	0.0022	27.461	0.0752	0.0251	0.0251	5.9812	5
Tsodoreti	396	13	0.01	123.58	0.3386	0.026	0.0097	119	0.326	0.0251	0.026	5.7594	5
Mukhattskaro	189	10	0.0048	58.981	0.1616	0.0162	0.0074	91.537	0.2508	0.0251	0.0251	5.9812	5
Nafetvzebi	76	11	0.0019	23.717	0.065	0.0059	0.0082	100.69	0.2759	0.0251	0.0251	5.9812	5
Natakhtari	1285	70	0.0325	401.01	1.0987	0.0157	0.052	640.76	1.7555	0.0251	0.0251	5.9812	5
Kotorsantkari	66	7	0.0017	20.597	0.0564	0.0081	0.0052	64.076	0.1755	0.0251	0.0251	5.9812	5
Buriani	60	5	0.0015	18.724	0.0513	0.0103	0.0037	45.768	0.1254	0.0251	0.0251	5.9812	5
Jigaura	174	12	0.0044	54.3	0.1488	0.0124	0.0089	109.84	0.3009	0.0251	0.0251	5.9812	5
Bitsmendi	524	18	0.0133	163.52	0.448	0.0249	0.0134	164.77	0.4514	0.0251	0.0251	5.9812	5
Old Kanda	1334	44	0.0338	416.3	1.1406	0.0259	0.0327	402.76	1.1035	0.0251	0.0259	5.7867	5
Skhaltba	11	1	0.0003	3.4328	0.0094	0.0094	0.0007	9.1537	0.0251	0.0251	0.0251	5.9812	5
Terami	63	2	0.0016	19.66	0.0539	0.0269	0.0015	18.307	0.0502	0.0251	0.0269	5.5696	5
Kevliani	146	5	0.0037	45.562	0.1248	0.025	0.0037	45.768	0.1254	0.0251	0.0251	5.9812	5
Satovle	0	0	0	0	0	0	0	0	0	0	0	0	0
Bevreti	41	2	0.001	12.795	0.0351	0.0175	0.0015	18.307	0.0502	0.0251	0.0251	5.9812	5
Tabaruki	7	1	0.0002	2.1845	0.006	0.006	0.0007	9.1537	0.0251	0.0251	0.0251	5.9812	5
Lelobi	1	0	3E-05	0.3121	0.0009	0	0	0	0	0	0	0	0
Dzalaantkhevi	10	1	0.0003	3.1207	0.0085	0.0085	0.0007	9.1537	0.0251	0.0251	0.0251	5.9812	5
Nakhshirgora	4	0	0.0001	1.2483	0.0034	0	0	0	0	0	0	0	0
Chilaantkari	2	0	5E-05	0.6241	0.0017	0	0	0	0	0	0	0	0
Agaraki	67	2	0.0017	20.909	0.0573	0.0286	0.0015	18.307	0.0502	0.0251	0.0286	5.2371	5
City Mtskheta	8446	319	0.9738	3428.4	9.3928	0.0294	0.9726	3423.9	9.3806	0.0294	0.0294	5.0943	5
Karsani	1	0	0.0001	0.4059	0.0011	0	0	0	0	0	0	0	0
Mukhadgverdi	176	7	0.0203	71.441	0.1957	0.028	0.0213	75.133	0.2058	0.0294	0.0294	5.101	5
Daba Zahesi	50	2	0.0058	20.296	0.0556	0.0278	0.0061	21.466	0.0588	0.0294	0.0294	5.101	5

There are a total of 48,154 people and 1,674 bins in the Mtskheta-Mtianeti region. Since and because I mentioned above that there are insufficient bins in Mtskheta, I increased the number of bins to 1674 bins according to the villages. I have also added bins in those villages, in which there are no bins as of today. The principle of increasing bins is as follows:

I want to increase the number of days when the average trash is filled. I made an assumption that the garbage can will be filled in an average of 5 days. I chose 5 days because it is close to the working week and the cars should come to each bin at least once or twice.

In order to calculate the total maximum number of tons of waste that should be transported by garbage trucks in Mtskheta municipality, we used the maximum of two methods. In Method 1, we counted according to the population, in Method 2 according to the number of bins. Finally, I took into account the largest number by calculating these two methods, so that none of the counting methods were violated.

In rate of method 1, the share of the population is calculated, in Year the share of the population is multiplied by the amount of waste in tons, in Day the waste received during the year is divided by 365, and in order to find out how many tons of waste are thrown into the bin per day, the number obtained in the Day column is divided by the number of bins on quantity.

In the rate of method 2, the share of the number of bins is calculated, in the Year column the figure obtained in the rate is multiplied by the residue allocated during the year, in the Day column it is divided by 365 and finally it is divided by the number of bins.

In the end, if none of the methods were violated, I took the calculations of method 1 and method 2, how many tons of garbage are thrown into the bin per day, the maximum of this.

As I mentioned above, unpressed garbage weighs 150 kg. To determine how many days the bin will be filled, I divided 0.15 tons by the amount of waste received in the maximum column. Accordingly, we received that waste will be disposed of every 5 days.

In order for the Geovision program to calculate the route of each car within 1 week, it was necessary to upload the following information:

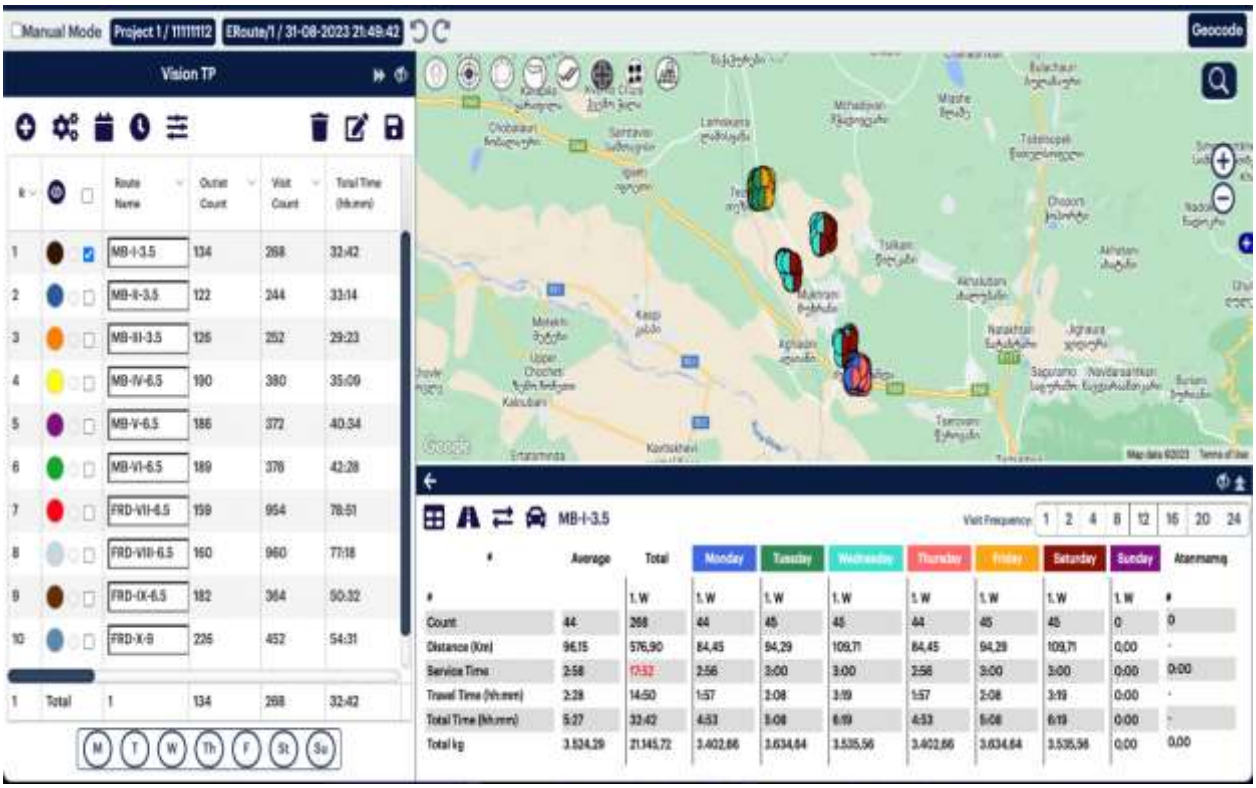
I took the villages, numbered the bins in these villages, so that it was easy to determine, I searched with the help of Google map the latitude and longitude of the villages included in each administrative unit, as well as the garbage dump and the Mtskheta garbage truck parking lot. I took the time needed to empty the bin of a garbage truck for 4 minutes, in 1 month or 4 weeks, I allowed the frequency of work of 1 garbage truck in the villages to be 8 days, since it works 2 days a week, and in Mtskheta 24 days, because every day the truck goes to empty the bins. There are 24 working days in a month. Cars that work twice a week will miss three days. Conditionally Monday-Thursday or Tuesday-Friday- or Wednesday-Saturday. They walk in Mtskheta every day from Monday to Saturday.

As a result, we got 10 routes.

MB-I-3.5	Small Kanda	Ksovrisi	Vardisubani	Vaziani	Old Kanda							
MB-II-3.5	New Nichbisi	Zemo Nichbisi	Saskhori	Qvemo Nichbisi	Khekordzi	Tsikhisdziri	Ksovrisi					
MB-III-3.5	Dzegvi	Ksani	Dzalaantkhevi									
MB-IV-6.5	Mukhrani											
MB-V-6.5	Dzalisi	Ereda	Tsilkani	Frezeti	Ufureti	Akhaldaba						
MB-VI-6.5	Navazi	Akhalubani	Misakcieli	Aghdgomliantkari	Natakhtari	Agaraki						
FRD-VII-6.5	City Mtskheta											
FRD-VIII-6.5	City Mtskheta											
FRD-IX-6.5	Lisi	Chardakhi	Tserovani	Gorovani	Tsodoreti	Mukhatskaro	Nafetvrebi	Skhaltba	Bevreti	Tabaruki	Mukhatgverdi	Daba Zahesi
FRD-X-9	Akhalsofeli	Tsinamdzgvriantkari	Shankevani	Mshralkhevi	Navdaraantkari	Sagurami	Tsitsamuri	Galavani	Ckhvaricham ia	Lelubani	Mamkoda	

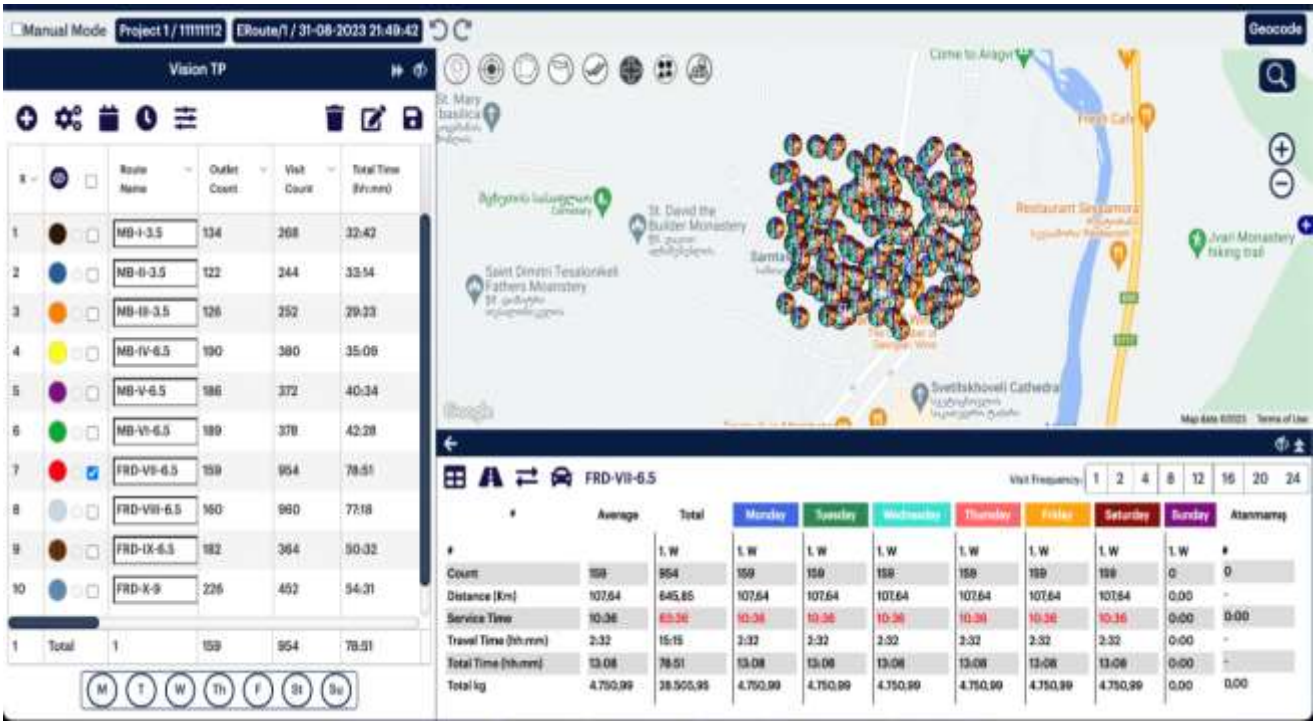
Outlet Count specifies how many bins each car will go through per day, in Visit count during the week, the cars that City of Mtskheta bins are served per day, the number of bins is multiplied by 6, and in the rest of the villages that go, the number of them is multiplied by 2. For example, the MB-I_3.5 vehile serves Small Kanda, Ksovrisi, Vardisubani, Vaziani and Old Kanda's bins. It should go around 134 bins per day, and 134*2= 268 bins per week, it will take 32:52 minutes during the week.

With the help of the program, it is written in the route which car, which village, which bin should be delivered on which day. What distance will it travel per day, what will be the working time, travel time, total time, total weight, how many kg of waste will it press.



I am considering the MB-I-3.5 vehile.

On Monday, he will pick up 44 trash cans, travel 84.45 km, he will need 2:56 hours for work, he will lose 1:57 in the journey, a total of 4:53 hours. At the end of the day, there will be 3402.66 kg of waste on the truck.



According to the given plan, the garbage trucks of Mtskheta municipality will run out of time everywhere except Mtskheta. Regarding the current situation in Mtskheta, there are not enough garbage trucks, because emptying 159 bins every day, when it takes four minutes to empty one bin, the working time is 10:36 hours, 63:36 minutes per week, which is against the requirements of the Labor Code.

In conclusion, I would like to note that modern computer technologies have many opportunities for solving various optimization tasks. It is important that these technologies are implemented in both private and state structures. This will allow us to optimally use the budget funds and direct the freed funds to solve other social and economic problems of the region.

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