

Evaluation of key figures of waste collection as a planning and control tool for route optimization

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Problem statement

Background- Jordan

Objectives

Evaluation of key figures of waste
collection

Results of evaluation in three
municipalities

Costs analysis

Conclusion / Recommendation



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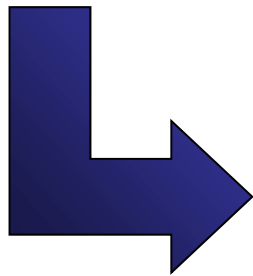
Evaluation of key figures of waste collection

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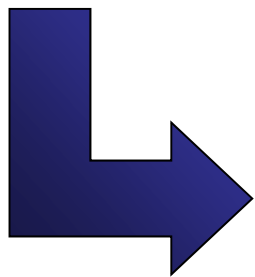
Conclusion / Recommendation

- Grown disposal structures in many municipalities
- Route planning on the basis of experience
- No structured key data oriented route planning
- No / hardly any adjustments to changes
- Lacking reporting and documentation
- Inefficient and expensive waste collection (60-80% of SWM chain).



**Decision-making and
actionable key figures are missing!**

- Controlling of disposal logistics with help of performance- and cost key-figures as essential planning parameters
- Steering based on evaluated planning figures for
 - work processes
 - performance targets
 - working time regulations
 - etc.
- Continuous improvement in terms of efficiency and productivity



**Development of a
practical control tool necessary!**

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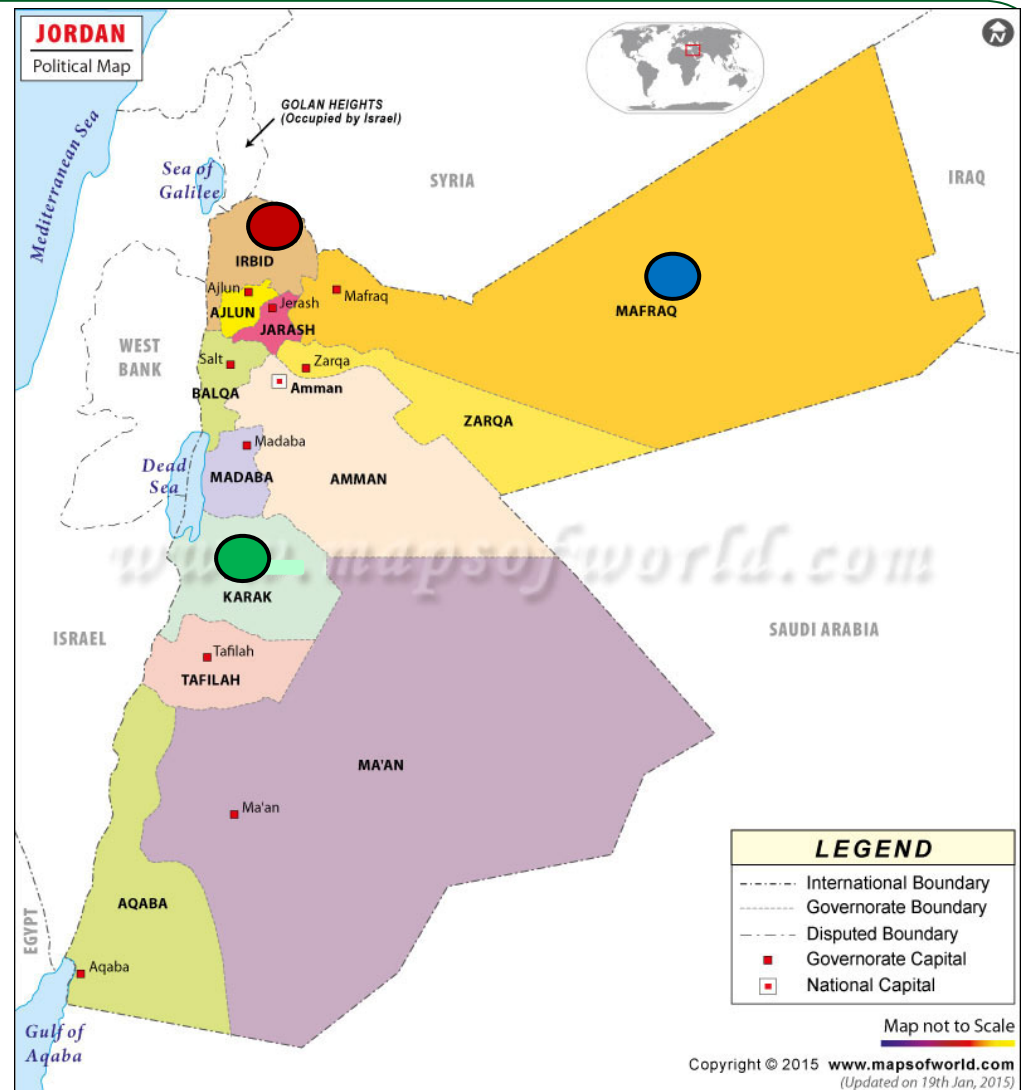
- Study area description -

Jordan is home to 7.3 million inhabitants in a surface area covering around 89.328 km².

● **Irbid:** It has the second largest metropolitan population in Jordan after Amman, with a population of around 1,088,100, and is located about 70 km north of Amman.

● **Al-Mafraq:** It's located to the north-east of Amman, capital of Jordan, with a population of 287,300.

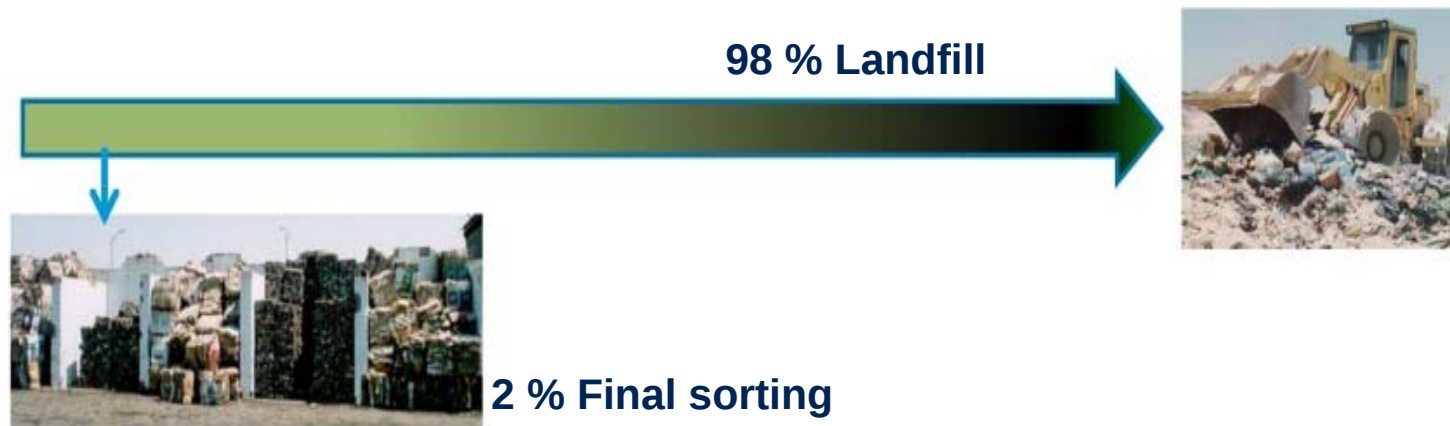
● **Al-Karak:** It's located to the south-west of Amman. The estimated population is about 239,000.



Background- Jordan

- Facts & Figures -

- Average daily waste generation per capita in Jordan is 0.9 kg/day.
- Quantities of MSW generated in Jordan : 4600 ton/day = 1,679,000 ton/year.
- More than 98% of the wastes generated in Jordan are deposited in different standard landfill without any treatment.
- No value of waste.



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- **The main objective** of this study was to estimate the key indicators via GIS techniques as a planning and control tool to optimize the routing network used for waste collection and transportation to the landfill or/and transfer station.
- *The specific objectives* of this research are to:
 - provide a comprehensive overview of the current situation of the waste management system in Jordan.
 - optimize the routing network used for waste collection and transportation.
 - track the overall operational cost (vehicles and staff) for collection, transfer and transportation of solid waste including cost analysis .
 - determine the best scenarios for waste collection with regard to travel distance and time as well as cost.
 - conduct feasibility studies including cost-benefit analysis for each suggested scenario and compared to the current situation.
 - Recommendation for adopted waste collection system.

Problem statement

Background- Jordan

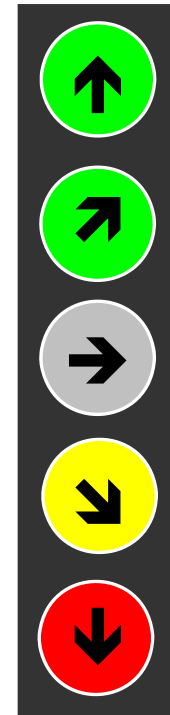
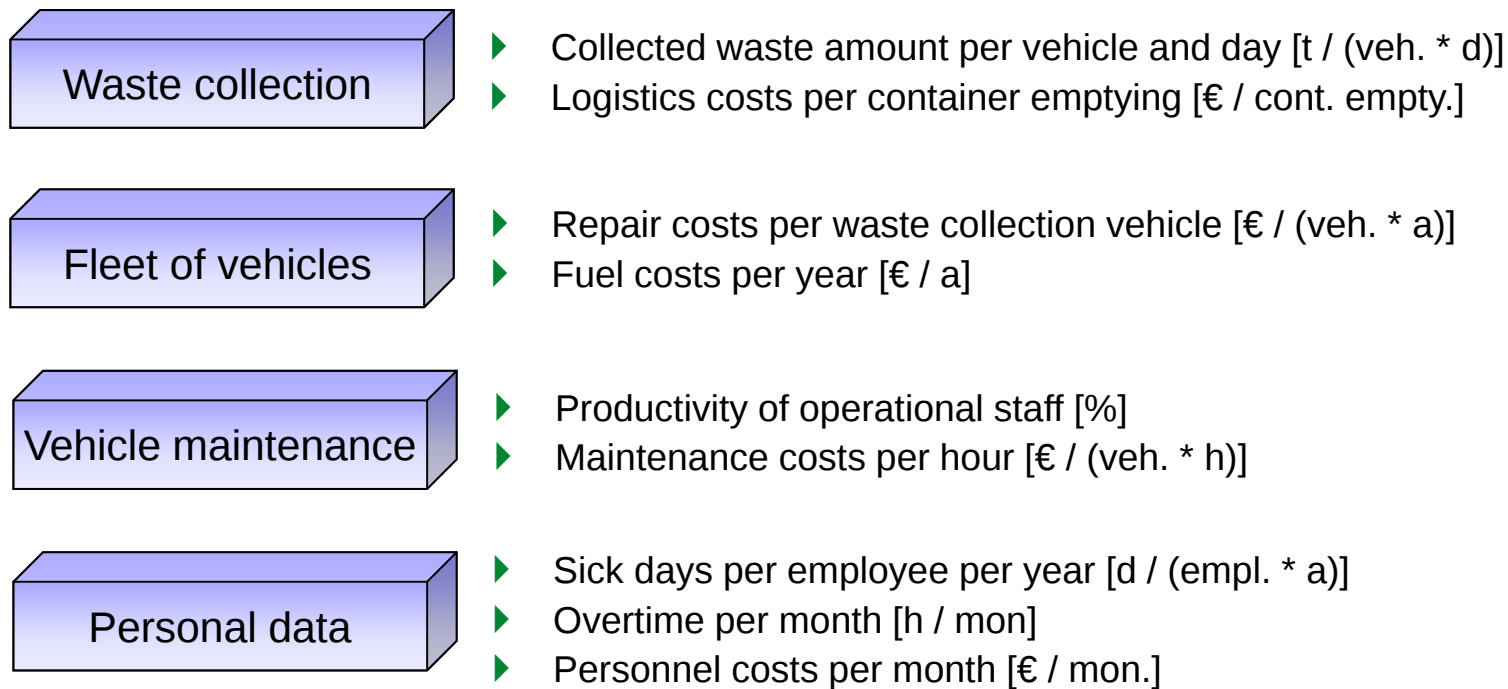
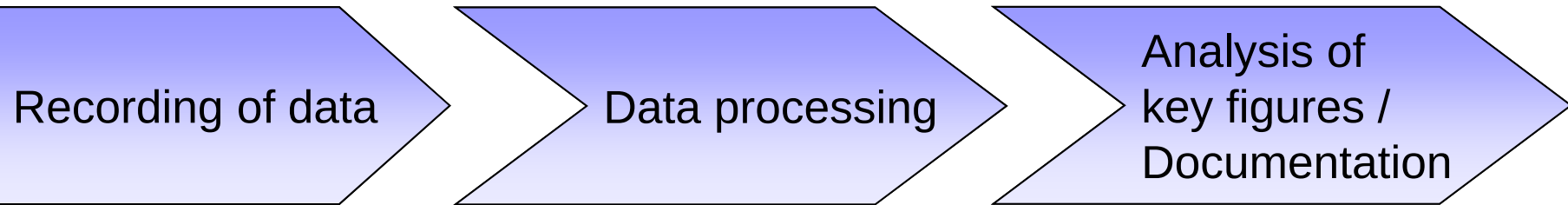
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Evaluation of key figures of waste collection

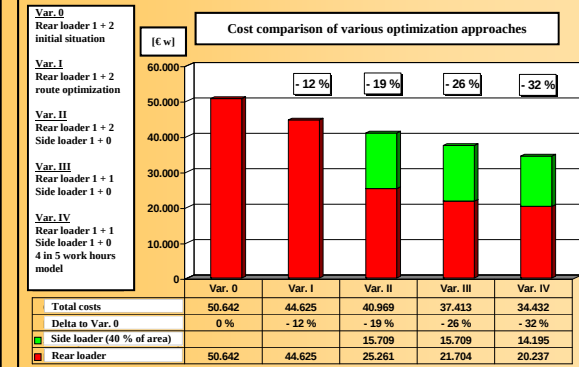
- standard analytical method -



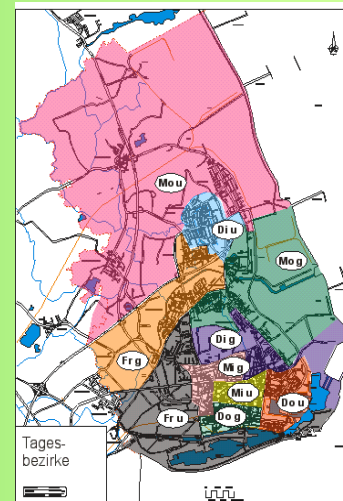
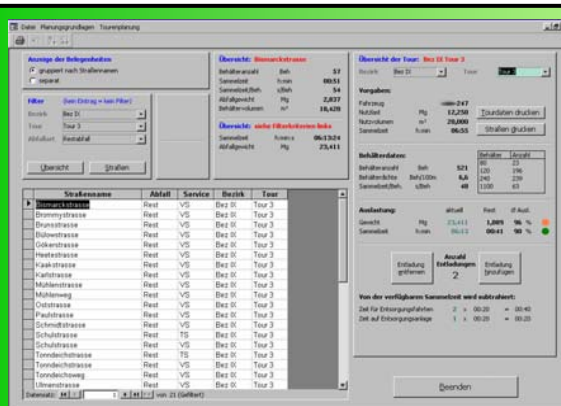
Analysis of operating-
and organization data



Survey of performance
parameters



Research of different
optimization versions



No.	Key performance- / costs-indicator (abstract)	Unit
1	Container units per vehicle and collection day (route)	[cu/(veh.*d)]
2	Collected waste amount per vehicle and day	[t/(veh.*d)]
3	Collected container units per employee and hour	[cu/empl.*h]
4	Utilization of the vehicle payload	[%]
5	Percentage collecting time relative to total working time	[%]
6	Total distance per vehicle and day	[km/d]
7	Percentage collecting kilometers relative to total distance	[%]
8	Costs (vehicle + staff) per amount of waste collected	[€/t] or [€/m ³]
9	Costs (vehicle + staff) per emptied container	[€/cu]
10	...	

- Further data, e.g.
 - waste amount per inhabitant and year [kg/(inh.*a)]

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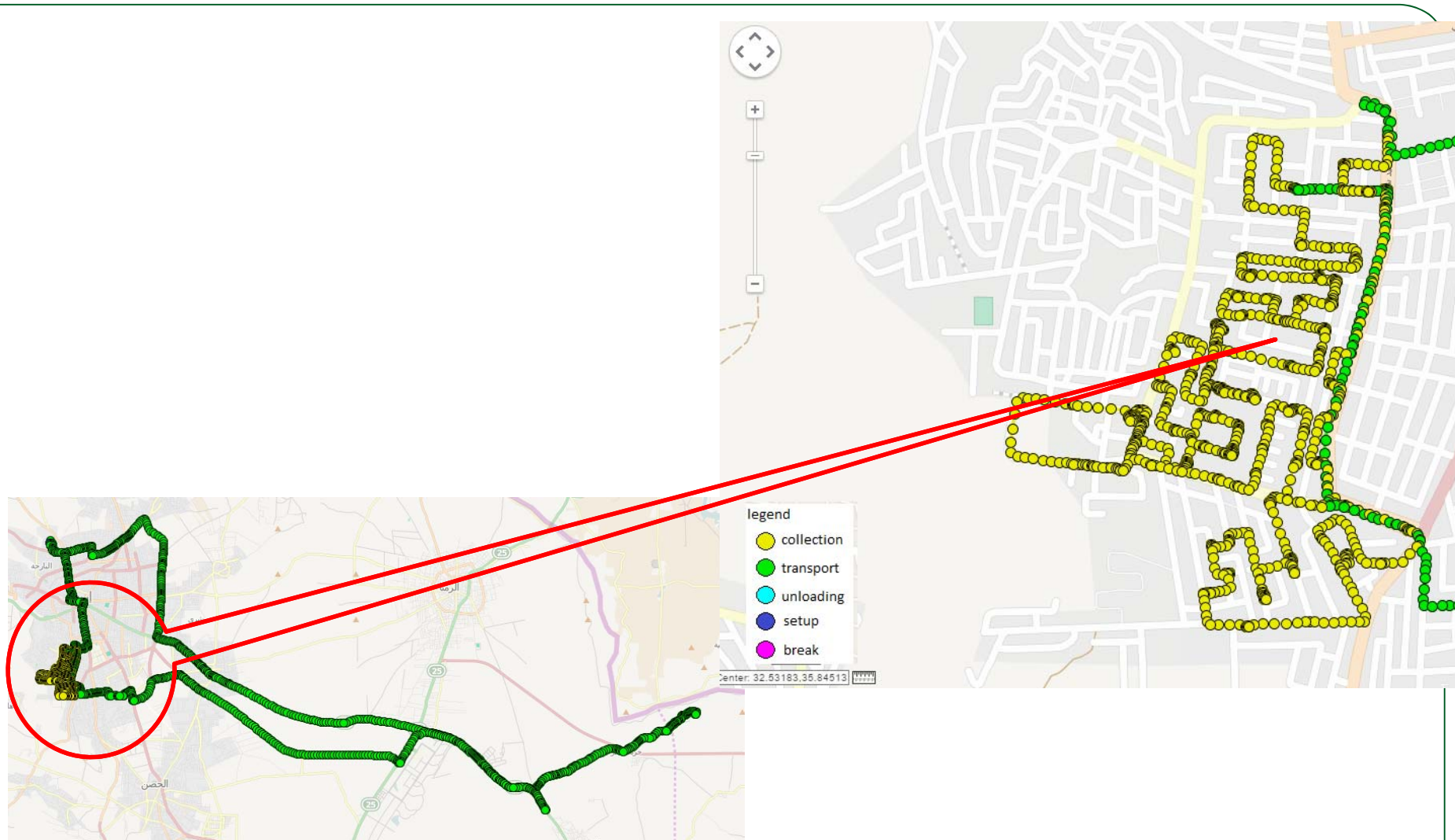
Results of evaluation

- overview of analyzed waste collector routes -

Study area	Sampling distribution					
	Collection vehicle/ crew	Shift A	Shift B	Shift C	Shift D	Total
Irbid*	3-axis					
	Two persons	7	3	0	0	10
	2-axis					
	Two persons	12	6	1	1	20
	One person	3	4	1	1	9
	Small vehicle					
	Two persons	2	1	0	2	5
	One person	1	0	0	0	1
	Total	25	14	2	4	45
Mafrq	3-axis					
	Three persons	0	0	3	0	3
	Two persons	1	2	1	2	6
	2-axis					
	Two persons	10	5	2	0	17
	Total	11	7	6	2	26
Karak	3-axis					
	Two persons	2	0	1	0	3
	2-axis					
	Two persons	4	1	0	0	5
	Small vehicle					
	Two persons	6	0	0	0	6
	Total	12	1	1	0	14
Total routes analysed for the three cities						87
* There were additional staff in collection areas (street workers)						

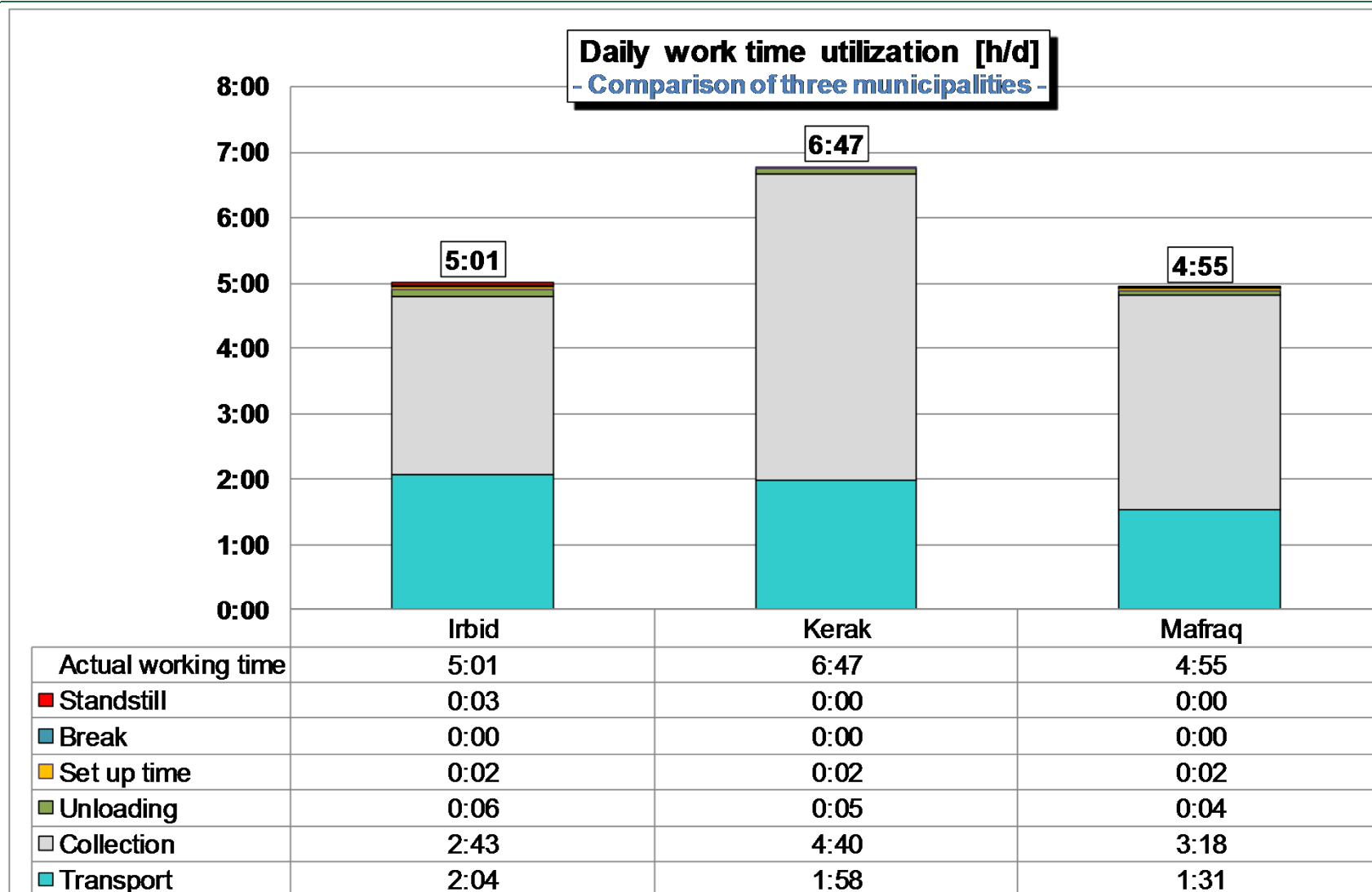
Results of evaluation (Irbid municipality)

- example of one collection route -



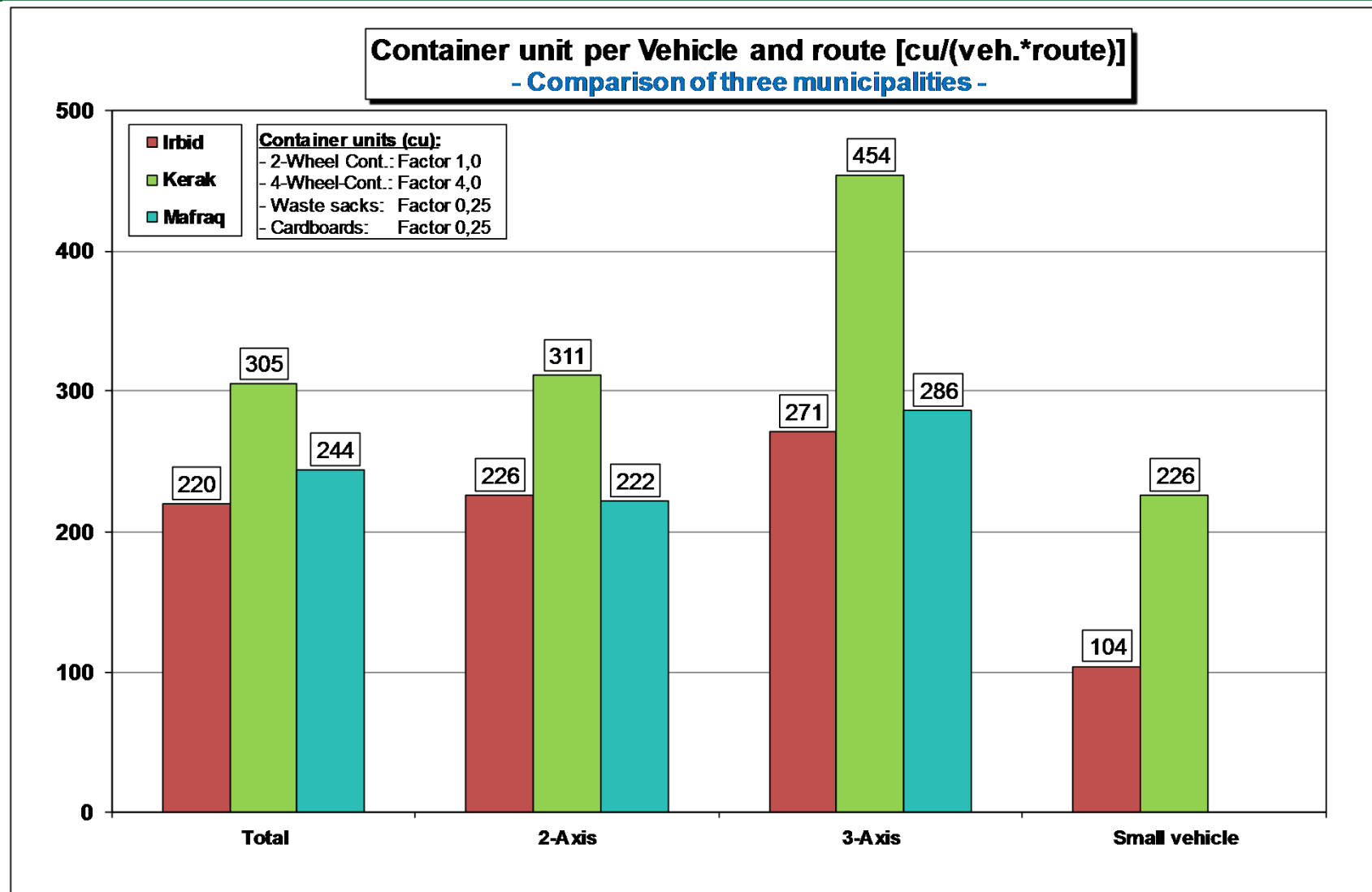
Results of evaluation

- comparison with other cities -



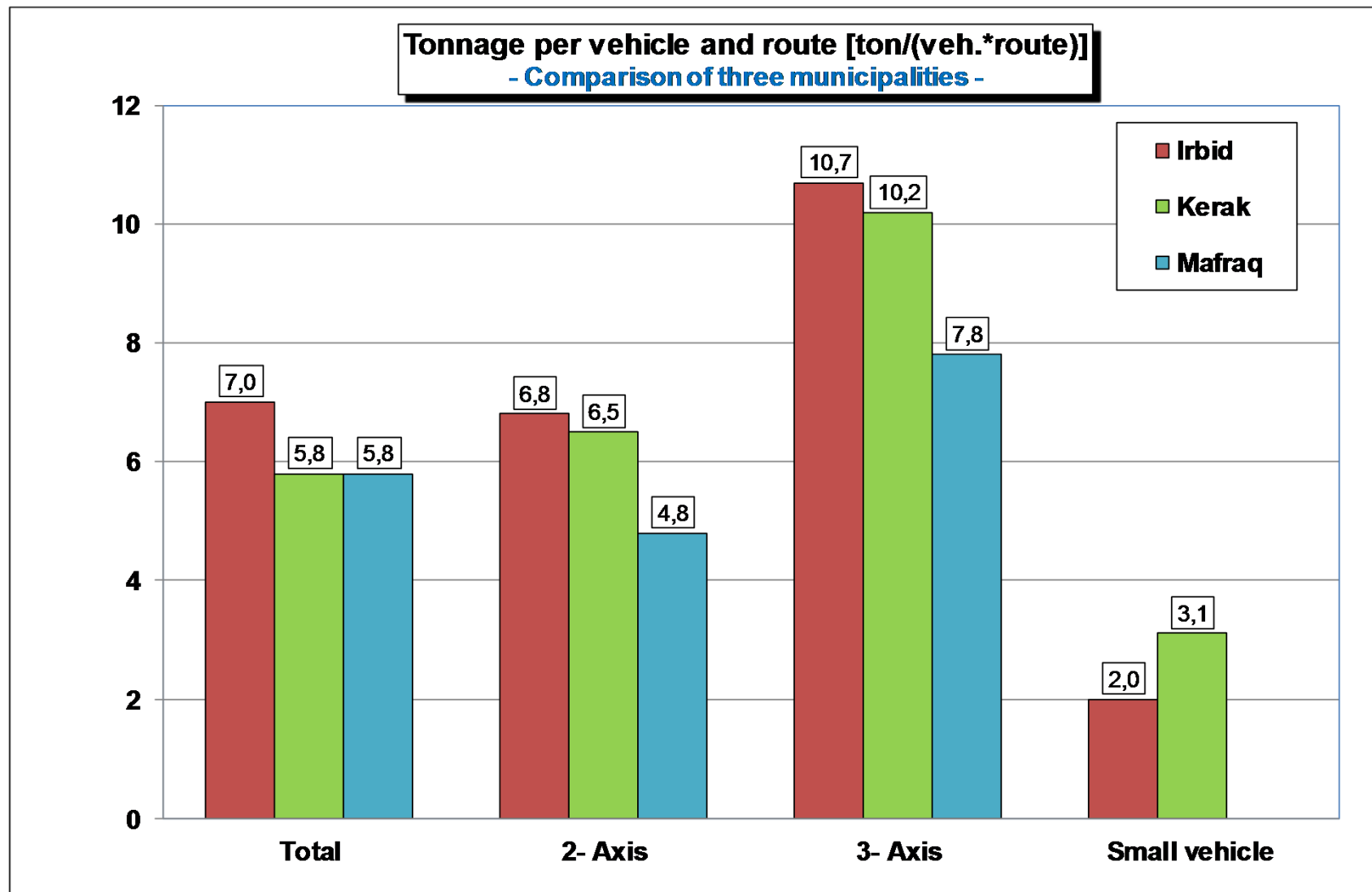
Results of evaluation

- comparison with other cities -



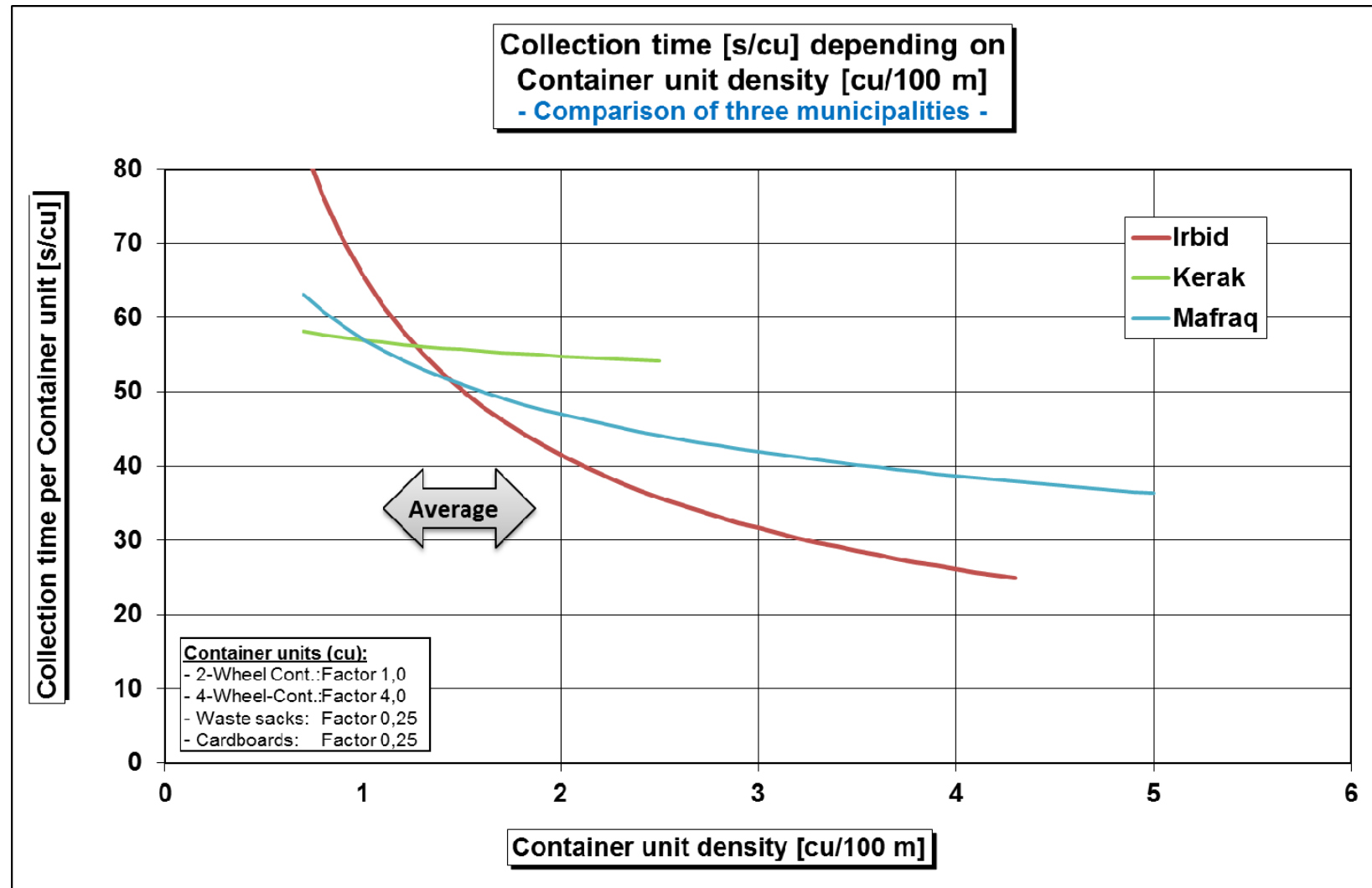
Results of evaluation

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Results of evaluation

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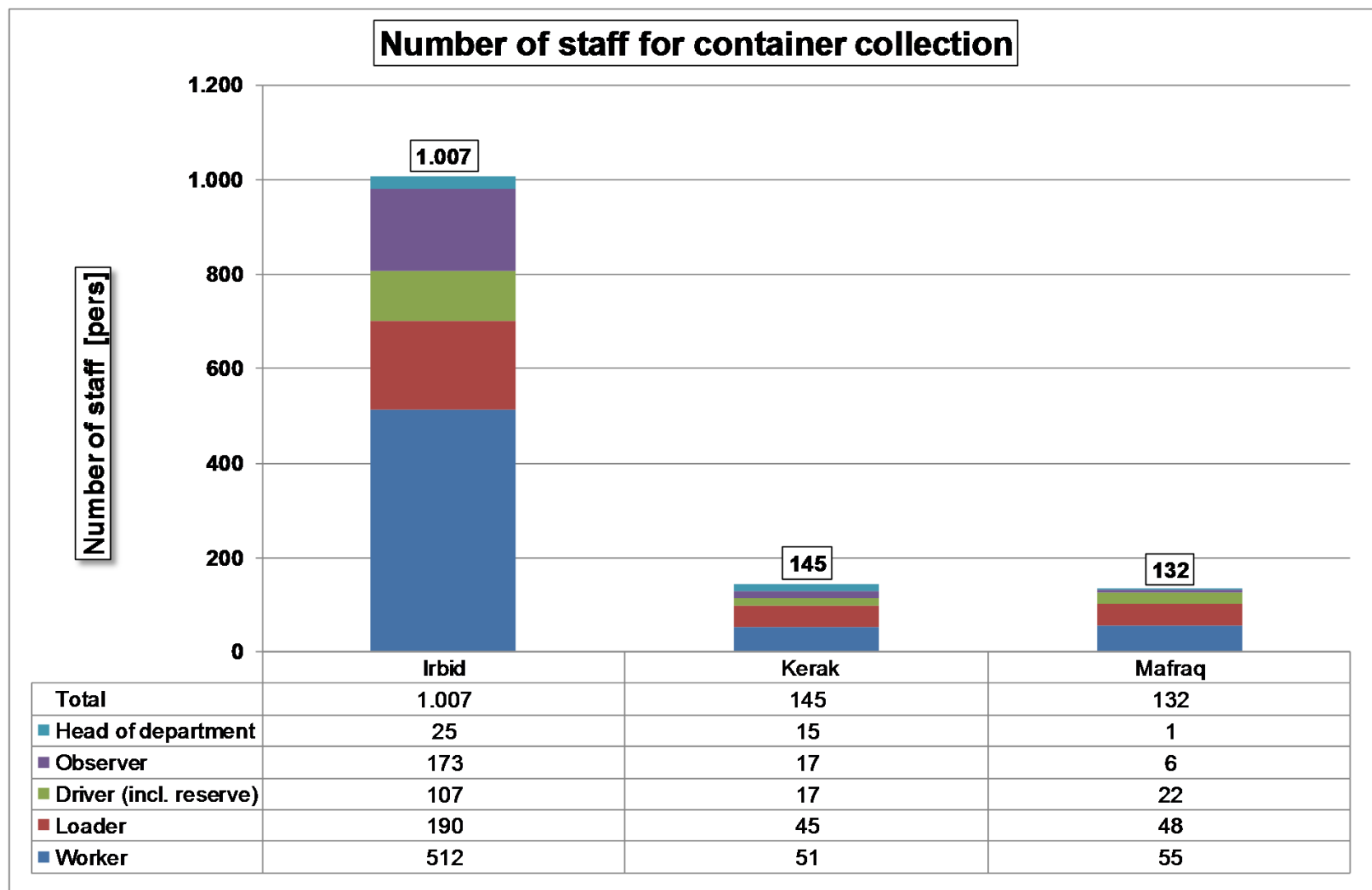
Costs analysis

- basis of calculation -

Basis of calculation	Analysed data
Analysis of staff	➤ number of employees ▪ head of Department ▪ observer ▪ driver ▪ loader ▪ street worker ➤ personal costs ▪ monthly staff salaries ▪ overhead ▪ reserve
Analysis of vehicles	➤ number of vehicles ▪ vehicles for container collection ▪ vehicles for bulky waste ▪ vehicles for transfer station ▪ other vehicles ➤ vehicle costs ▪ capital cost ▪ fuel costs ▪ oil costs ▪ maintenance costs
Analysis of routes	➤ number (container collection, bulky waste, transfer station) ➤ routes per day ➤ number of driver, loader and worker per vehicle and route
Analysis of container	➤ number of container ➤ container costs ▪ capital cost ▪ maintenance
Calculation of rates per hour	➤ personnel ▪ Head of department ▪ Observer ▪ Driver ▪ Loader / Worker ➤ vehicles ▪ 3-Axis ▪ 2-Axis ▪ Small vehicle ▪ 6-Axis

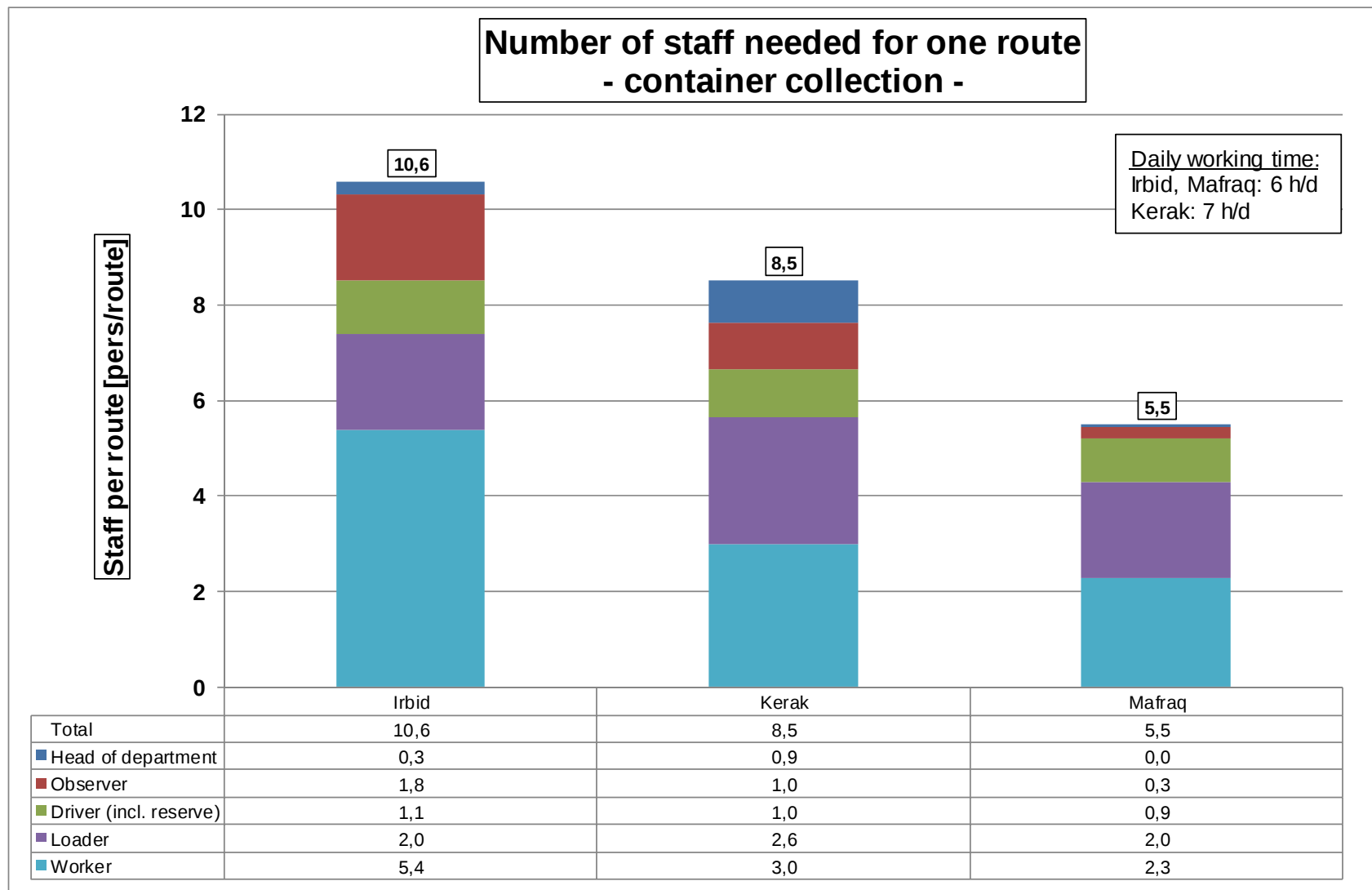
Costs analysis

- basis of calculation -



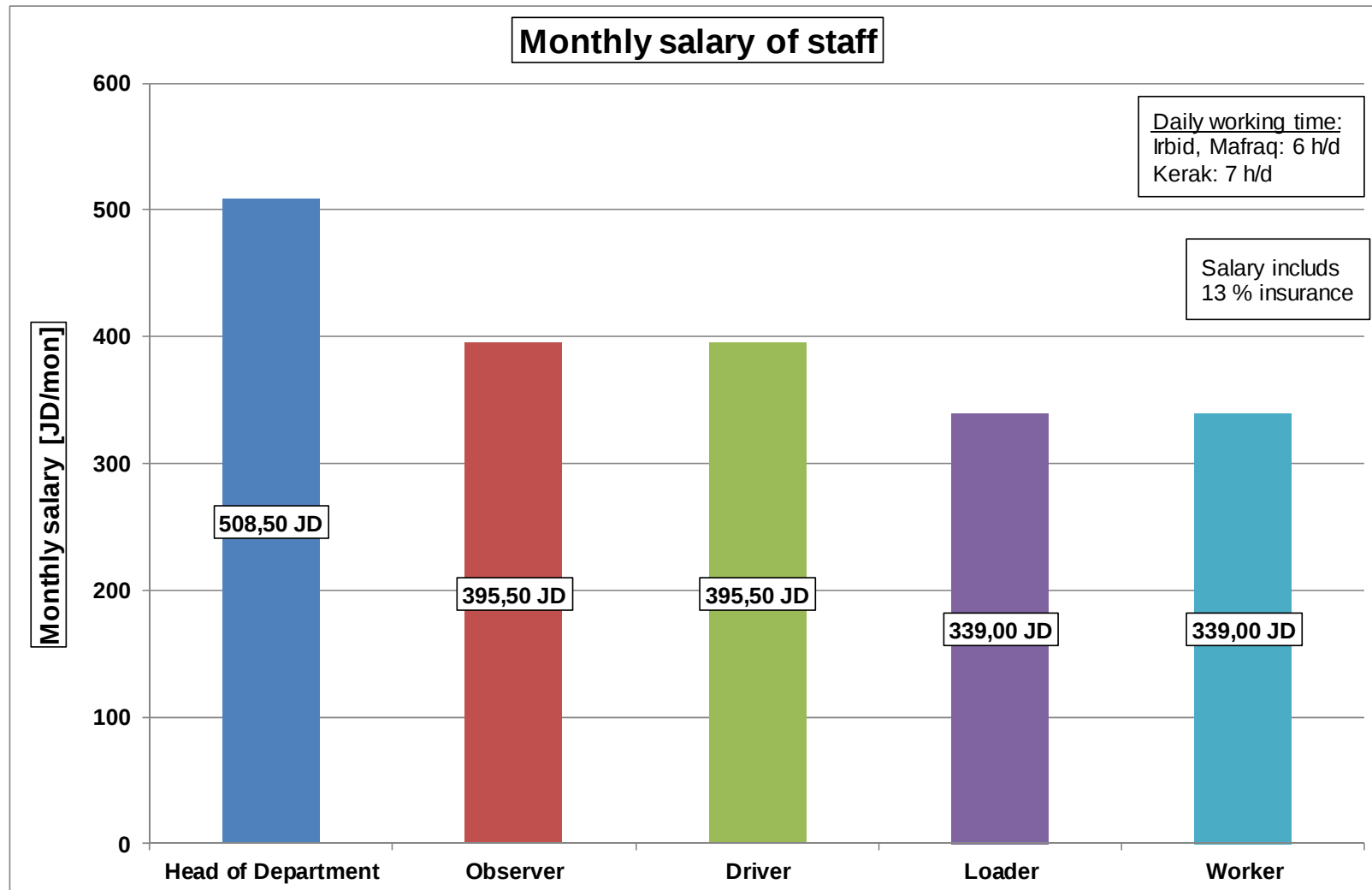
Costs analysis

- basis of calculation -



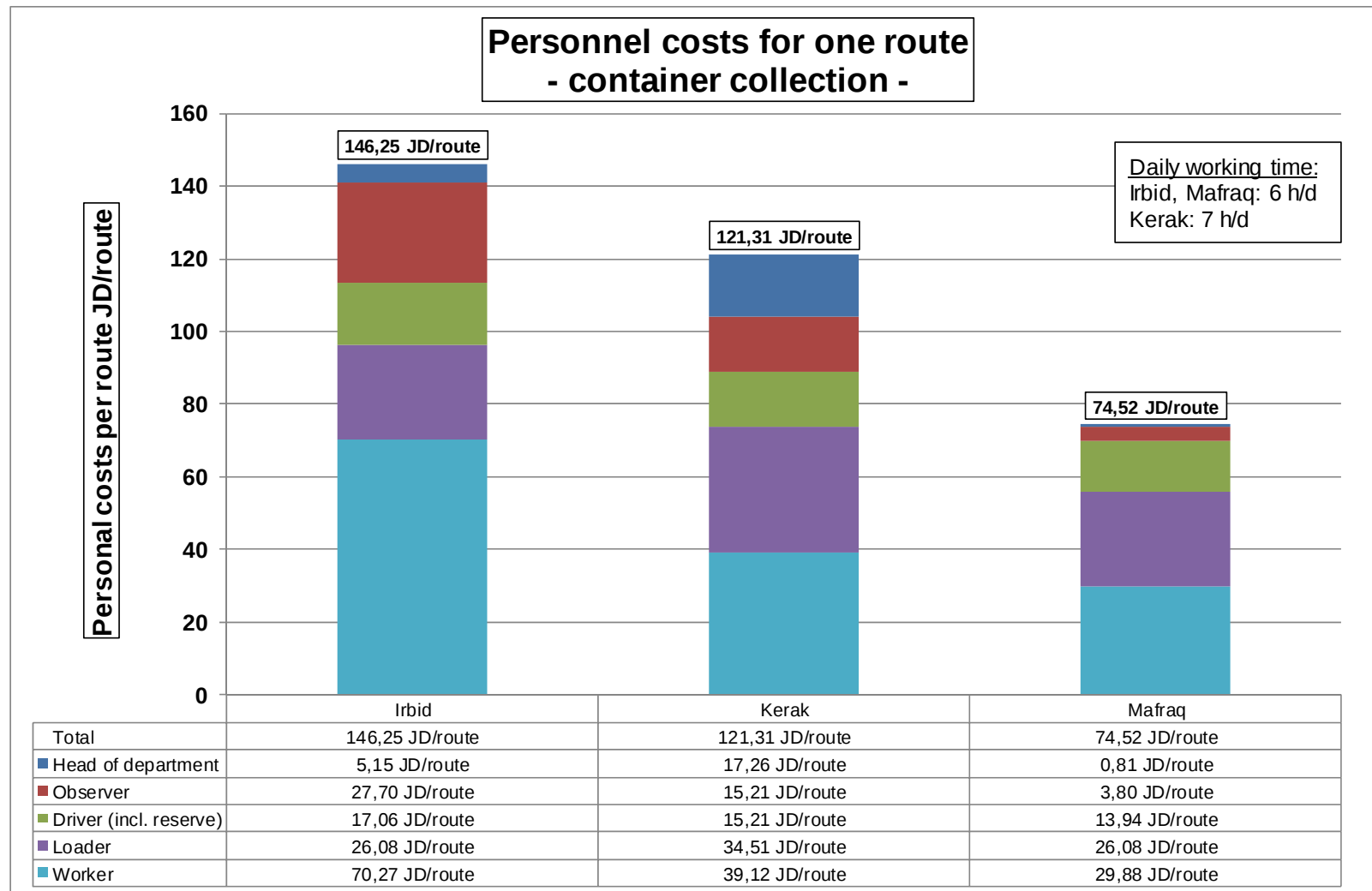
Costs analysis

- basis of calculation -



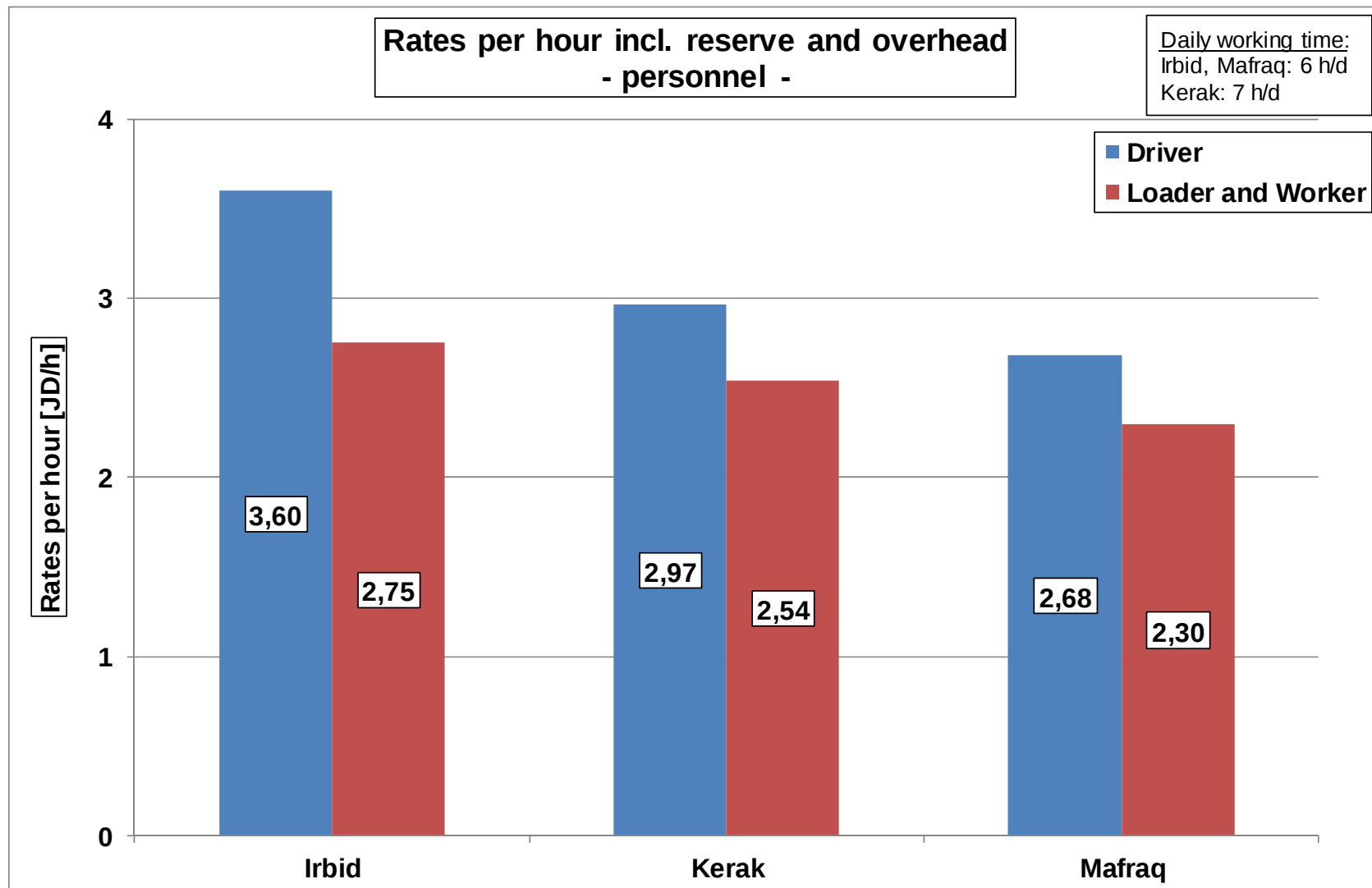
Costs analysis

- basis of calculation -



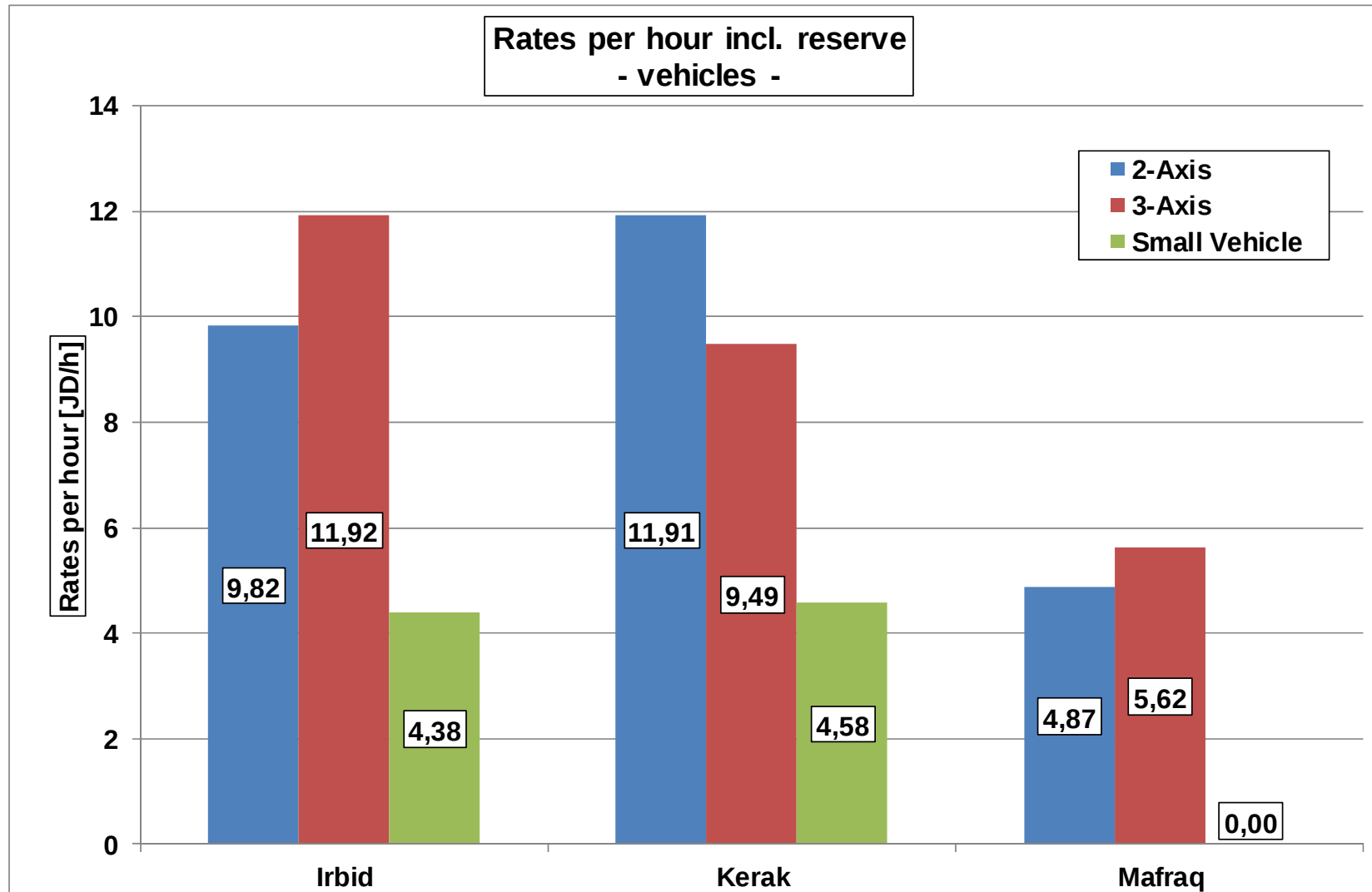
Costs analysis

- basis of calculation -



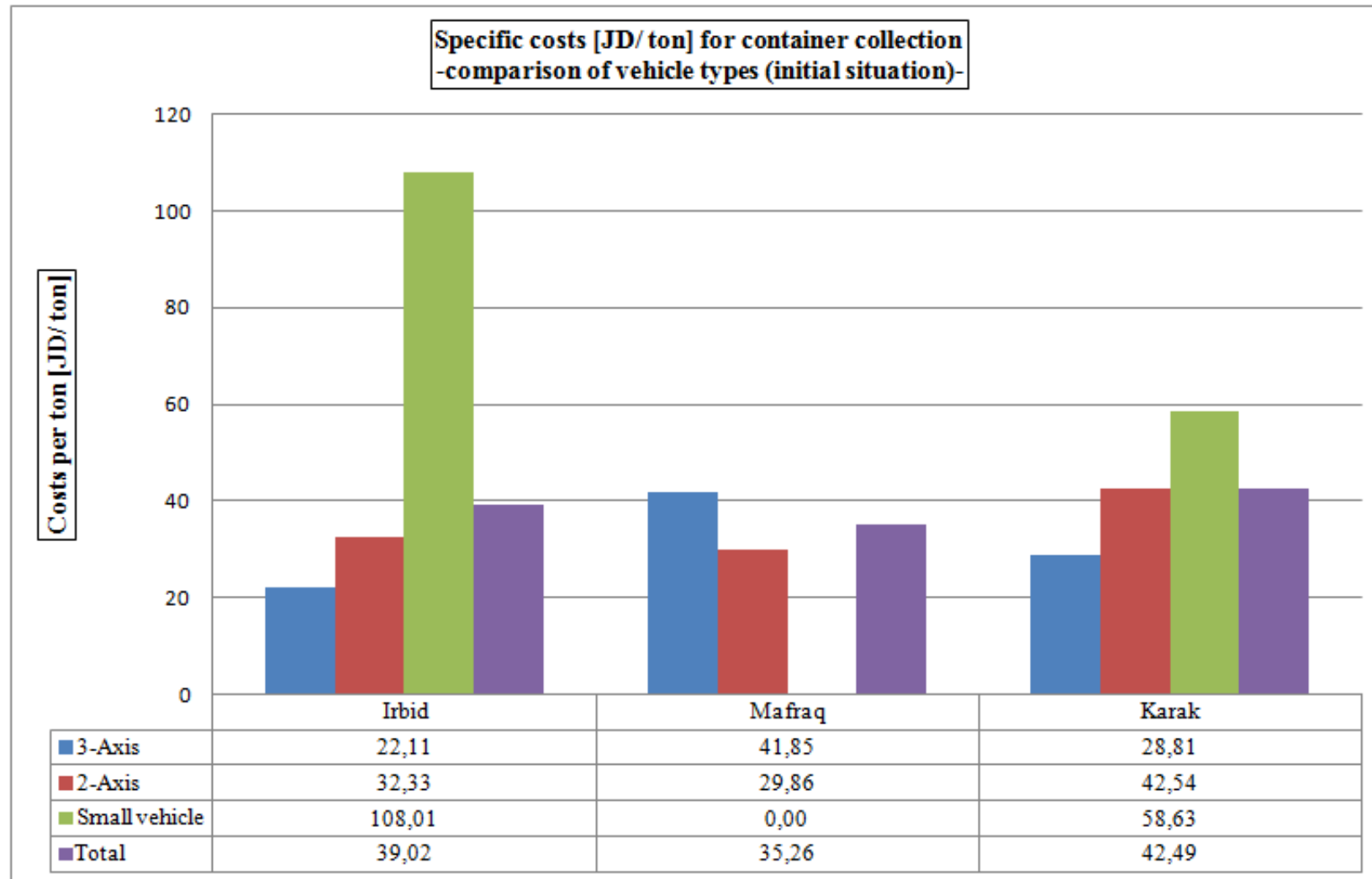
Costs analysis

- basis of calculation -



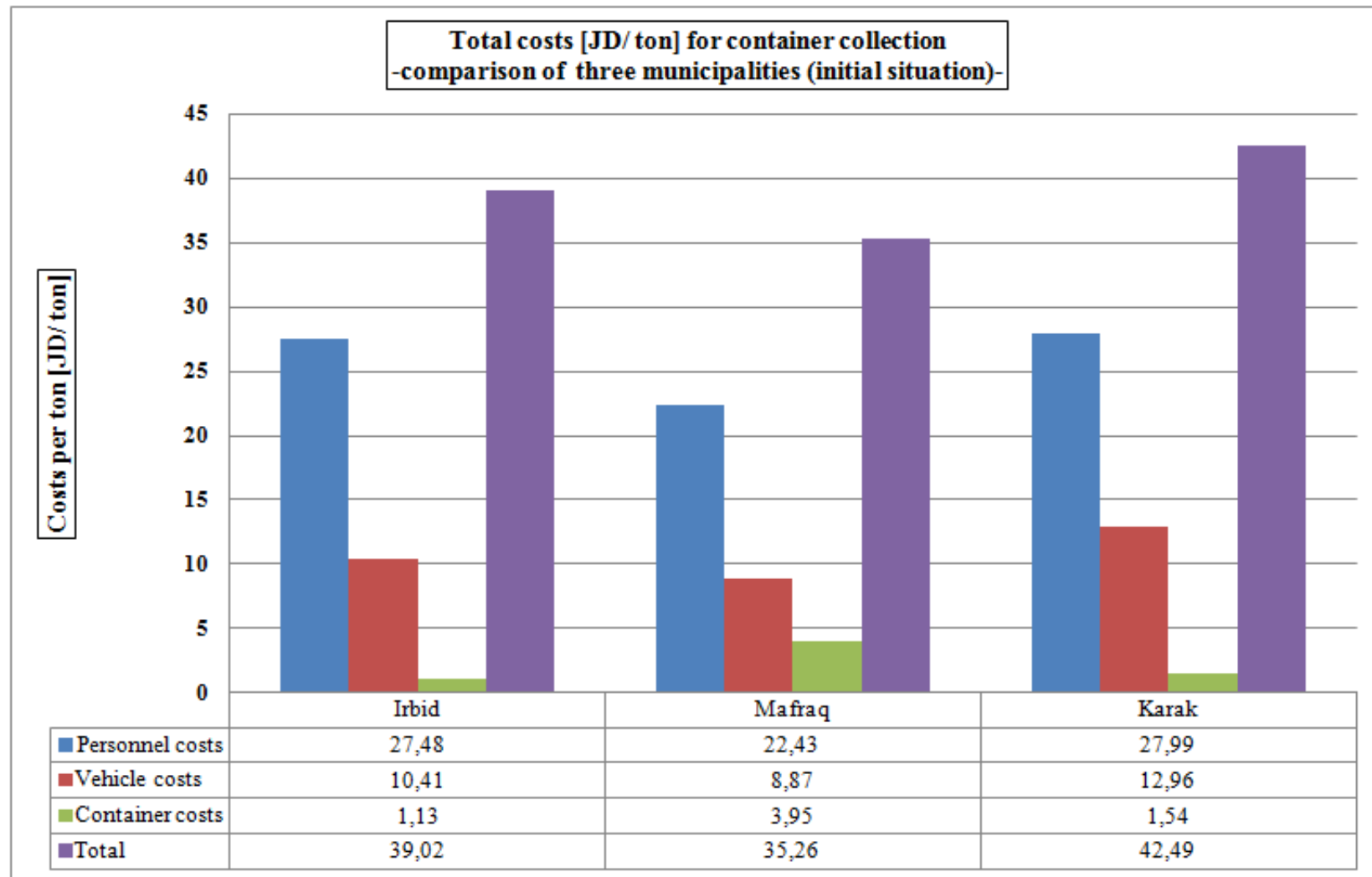
Costs analysis

- specific vehicle costs -



Costs analysis

- total costs -



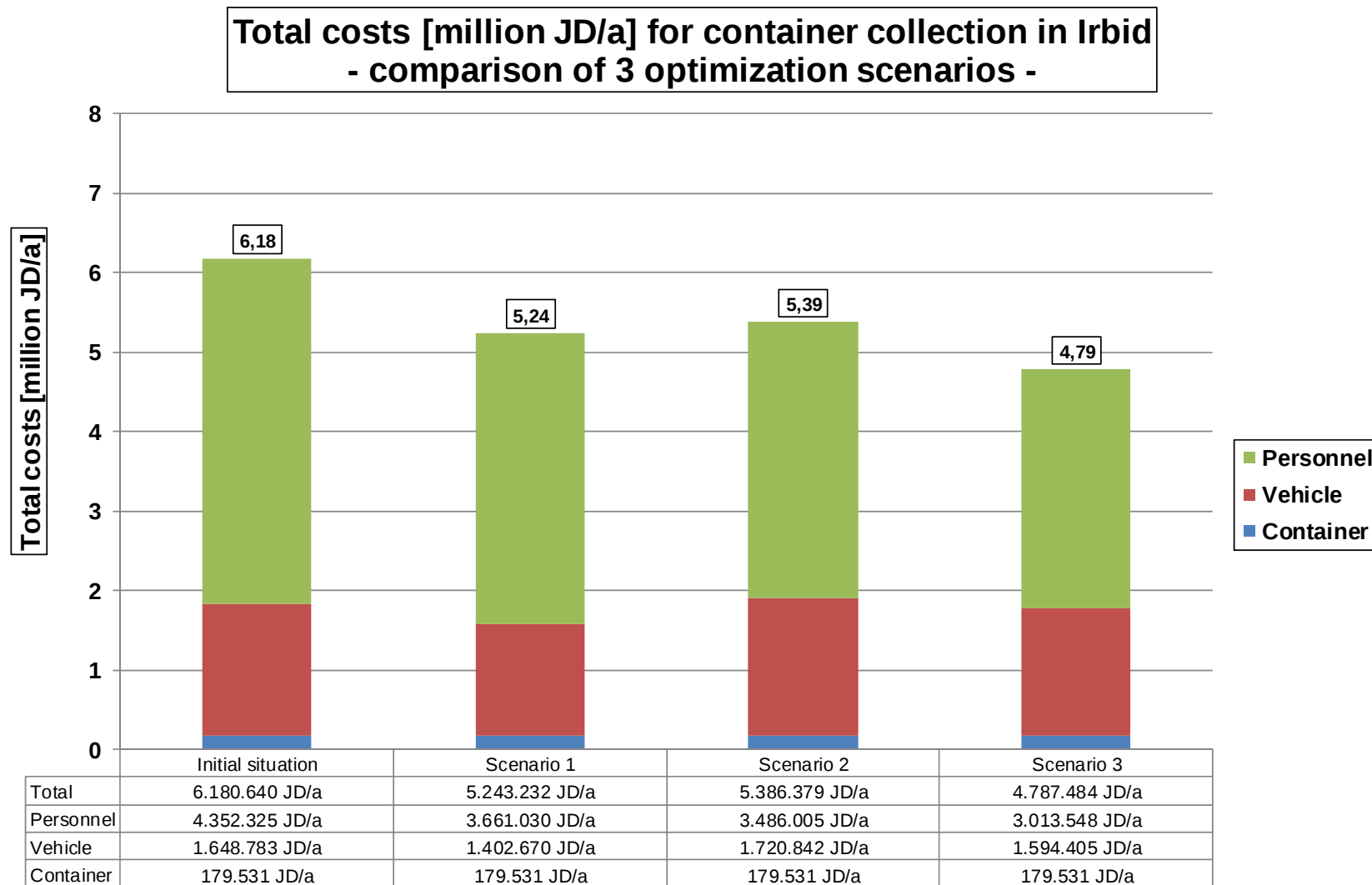
Costs analysis

- calculation of different scenarios costs -

Scenario	Description	Target	
		Irbid Municipality	Karak Municipality
0	Initial situation (working time as current situation)	- daily working time: 5:00 h/d - set-up time / paid breaks: < 0:15 h/d - utilization of payload: 90 to 95 % for all vehicles	- daily working time: 6:45 h/d - set-up time / paid breaks: < 0:15 h/d - utilization of payload: 90 to 95 % for all vehicles
1	Optimization of working time	- daily working time: 6:00 h/d - set-up time / paid breaks: 0:30 h/d - utilization of payload: 85 % for all vehicles	- daily working time: 8:00 h/d - set-up time / paid breaks: 0:30 h/d - utilization of payload: 85 % for all vehicles
2	Use of a transfer station (working time as current situation, no investment costs for building considered)	- transfer station at "Truck City" outside of Irbid for 2- and 3-axle vehicles - current transfer station for small vehicles at same place - reduction of distances for unloading (2-, 3-axle vehicles) - more 6-axle vehicles for transfer stations	- transfer station outside of Karak for 2-, 3-axle and small vehicles - reduction of distances for unloading for 2-, 3-axle and small vehicles - new 6-axle vehicles for transfer stations
3	Combination of scenario 1 and 2	- daily working time: 6:00 h/d - set-up time / paid breaks: 0:30 h/d - utilization of payload: 85 % for all vehicles - transfer station at Truck City outside of Irbid for 2- and 3-axle vehicles - current transfer station for small vehicles at same place - reduction of distances for unloading (2-, 3-axle vehicles) - more 6-axle vehicles for transfer stations	- daily working time: 8:00 h/d - set-up time / paid breaks: 0:30 h/d - utilization of payload: 85 % for all vehicles - transfer station outside of Karak for 2-, 3-axle and small vehicles - reduction of distances for unloading for 2-, 3-axle and small vehicles - new 6-axle vehicles for transfer stations

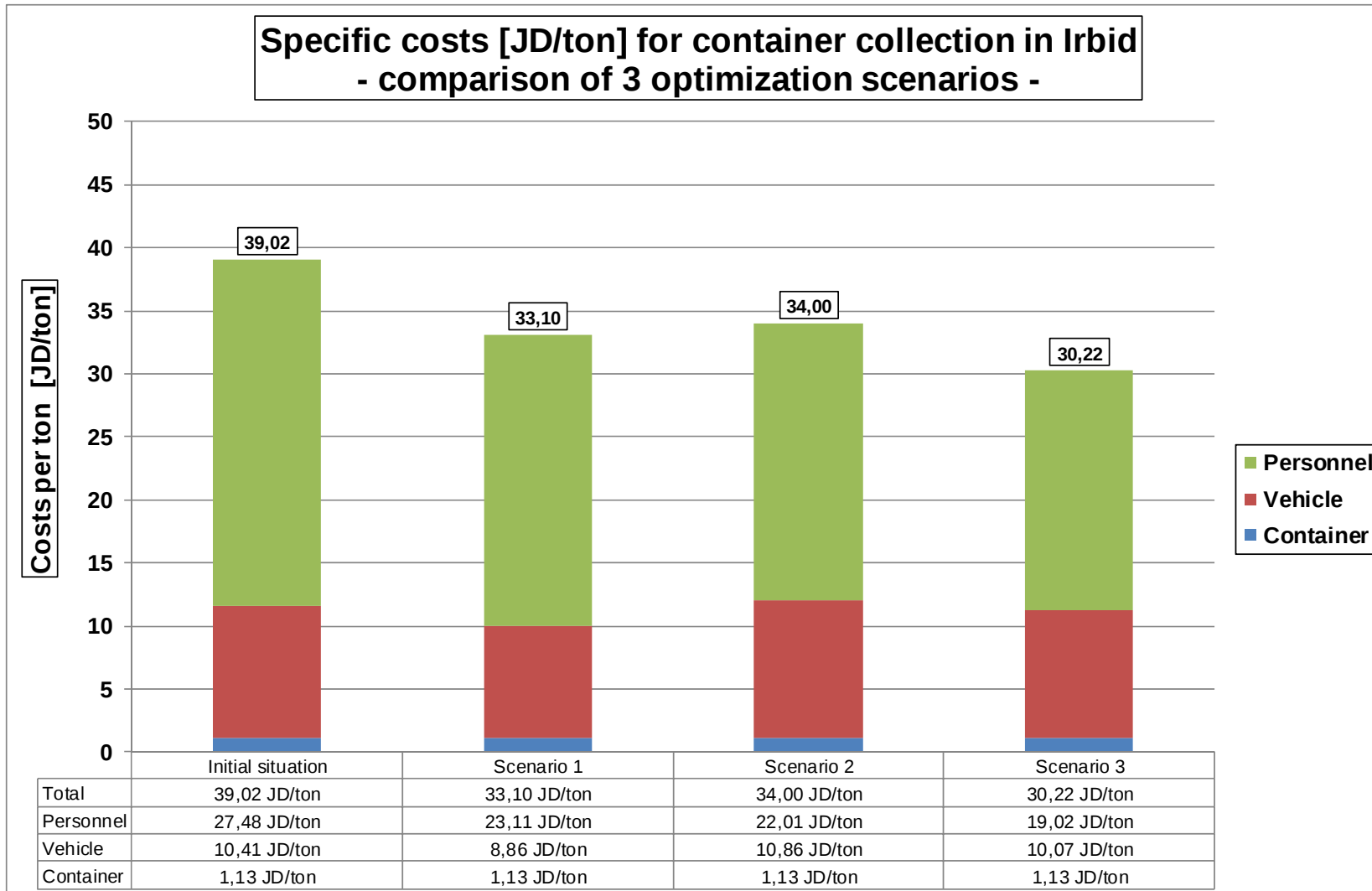
Costs analysis (Irbid)

- total costs -



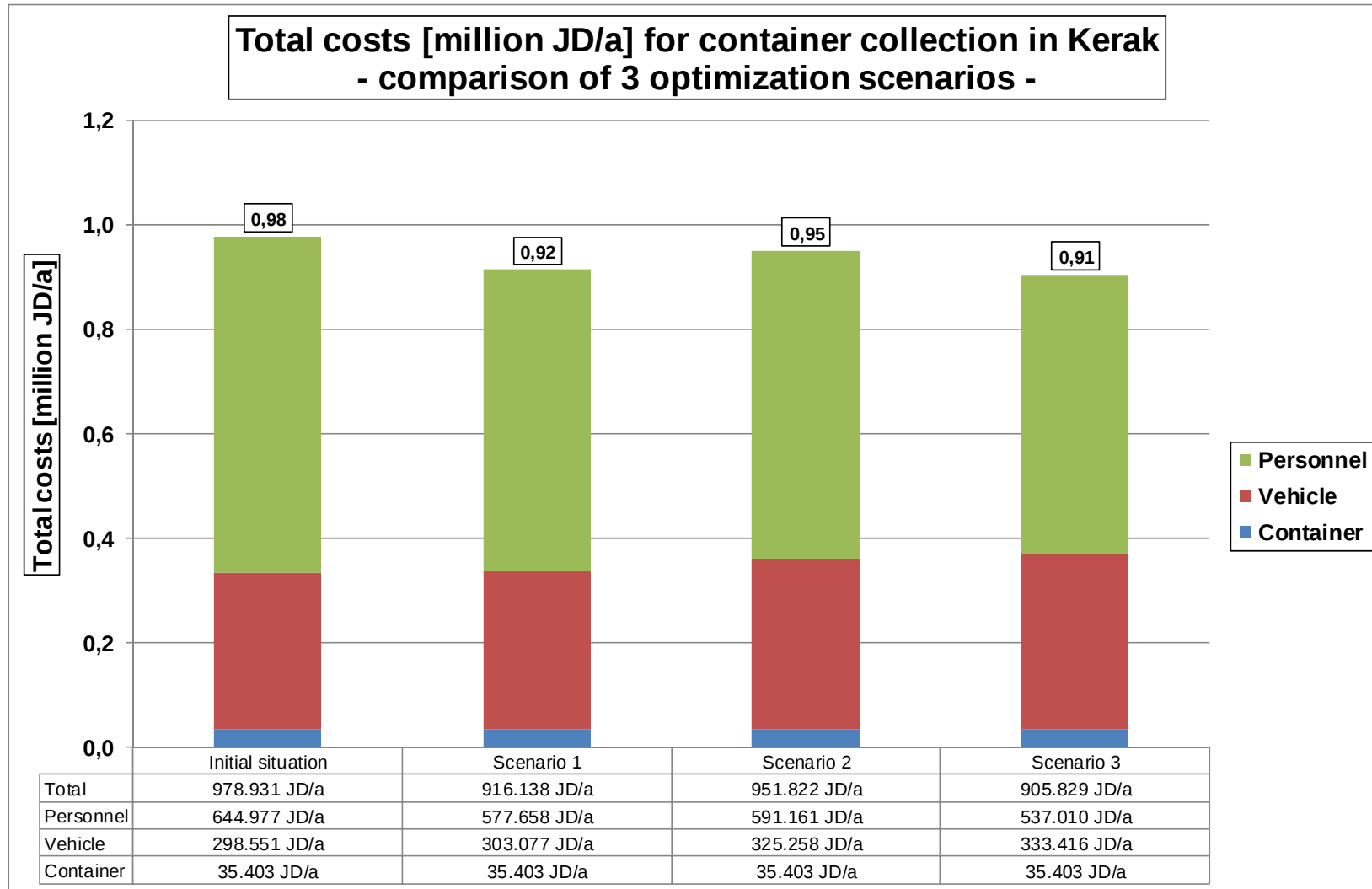
Costs analysis (Irbid)

- specific costs -



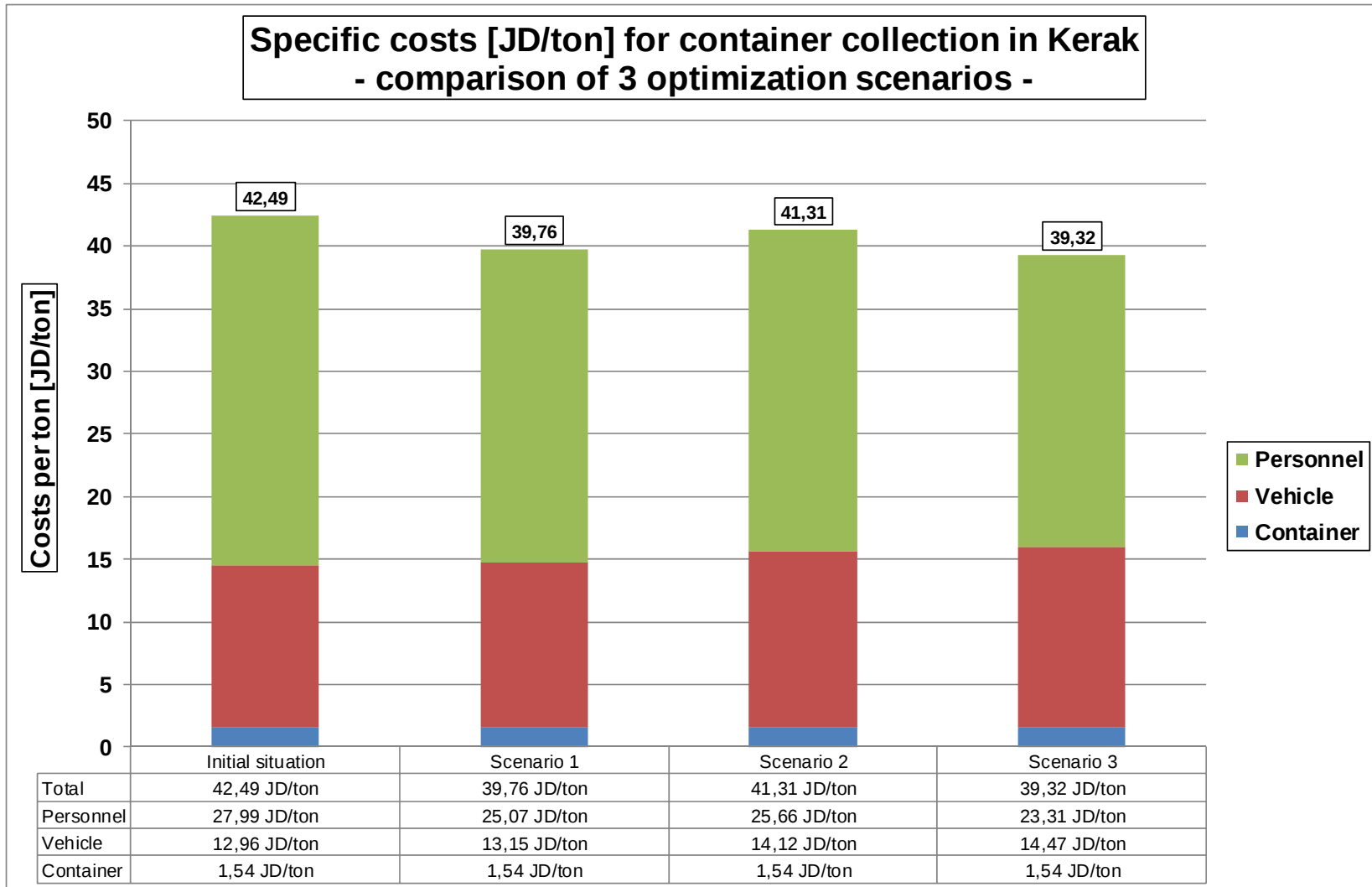
Costs analysis (Karak)

- total costs -



Costs analysis (Karak)

- specific costs -



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- Existing MSW collection systems still use up 80% of the total budget for a municipality's waste disposal operations.
- No structured key data-oriented route planning, inefficient and expensive waste collection and a lack of reporting and documentation was noticeable in the areas studied.
- Results demonstrate that the proposed scenarios' savings compared to the current situation in terms of the total cost for waste collection are 15%, 13% and 23% for scenarios 1, 2 and 3, respectively, in the city of Irbid and 6%, 3% and 8% for scenarios 1, 2 and 3, respectively, in the city of Karak. Although using the alternative scenarios was shown to provide significant savings, the operating time of the vehicles was reduced by 30%.
- This study can be used as a decision support tool by the municipal authorities for efficient management of the daily operations for moving solid wastes, load balancing within vehicles, managing fuel consumption and generating work schedules for the workers and vehicles.

- Development of optimization approaches
 - working time models / -utilization
 - e. g. Irbid / Mafrag consequent 6 h/route and Karak 7 h/route
 - reduce collection time
 - e. g. usage of more containers especially in Karak
 - reduce transport time
 - e. g. usage of transfer station in Irbid
 - e. g. usage of 3-axis vehicles
 - utilization balance - utilization of collecting routes
 - working time
 - container units per route
 - tonnage per route

Sponsors of the study



**Thank you for
your attention!**

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