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Benefits from Constructing a Dam Across the Vistula in Siarzewo in Terms of Transport and Environmental Protection

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Abstract. This paper presents the results of analyses that concern the benefits from the planned construction of a dam across the Vistula in Siarzewo. The simulated transport model developed in the VISUM environment has been used to determine the forecast traffic intensity, the value of traffic volume indices, transport activity, travel times of drivers and passengers as well as the costs of environmental impact. The above-mentioned characteristics have enabled to determine savings both in terms of traffic costs and environmental impacts resulting from the dam construction. The paper indicates that the implementation of the investment project improves traffic conditions on the road network and reduces the transport environmental impact in Kujawsko-Pomorskie Province. Moreover, it has been found that the revealed effects concern in particular the first years after the launch of the project. The development of the road network diminishes the role of the analysed investment project significantly.

Keywords: transport, traffic engineering, environmental impact of road traffic, transport activity, time spent in the network.

Conference topic: Environmental protection. Roads and Railways.

Introduction

The revitalization of inland waterways in Poland requires the involvement of large funds, amounting to more than 100 PLN billion, but spread over the period of 30 years. The project will bring significant benefits, amounting to ~300 PLN billion in the period. The most expensive investments in this scope include:

- the construction of the Vistula-Bug canal ~ 40.0 PLN billion,
- the Vistula restructuring for 36.9 PLN billion, and
- the construction of power dams on the Vistula ~16.0 PLN billion (Transport Week 2016).

The implementation of these investment projects would make the inland water transport one of the development levers for Poland, because inland navigation is a highly energy-saving means of cargo transport. For example, with one litre of fuel it is possible to transport 127 tonnes of cargo for the distance of one kilometre using a river vessel, while with a truck 50 tonnes and by rail 97 tonnes. External costs of river transport amount to (according to the European Commission studies) ~5 EUR per 1000 tonne-km and are almost five times lower than external costs of road transport amounting to ~24 EUR per 1000 tonne-km.

One of the recent concepts in the revitalization of the Vistula, mentioned in the document titled: The development strategy of the Kujawsko-Pomorskie 2020 – The modernization plan 2020+, is to build a dam with a water plant in Siarzewo, between Nieszawa and Chechocinek (Fig. 1). The costs of the construction are estimated at ~4.0 PLN billion. A provincial road will be conducted on top of the dam. Fig. 2 presents the view of the planned dam. The construction of a new bridge crossing will certainly improve traffic conditions in the road network of Kujawsko-Pomorskie Province.

This paper is aimed at presenting benefits from the construction of the dam across the Vistula in terms of traffic and taking into account the environmental impact.

Description of assumptions for the spatial analysis of traffic distribution

Traffic analyses (their results are presented hereunder) have been carried out with the current four-step transport simulation model for Kujawsko-Pomorskie Province. The model has been developed based on the comprehensive road transport studies and surveys conducted for the present condition among the local communities in this area in 2012–2013 (Szczuraszek *et al.* 2013–2014). The model was also the foundation for creating prediction models. In the prediction analysis of traffic and external travels (transit, absorbed, and generated), the prediction transport models for Kujawsko-Pomorskie Province have been used, developed in 2013 and described in (Szczuraszek *et al.* 2013–2014).

Prediction models, likewise the model for the present status, are based on the theory of the four-step computing stage comprising:

- generated demand for travels (travel origin, traffic origin)
- the selection of a destination (spatial distribution of travels and traffic in the matrix system),
- the selection of the means of transport for a journey, and
- the distribution of traffic in a transport network.

Fig. 1. Location of the planned dam across the Vistula (source: www.google.pl/maps)

Fig. 2. View of the planned dam on the Vistula in Siarzewo (source: http://torun.naszemiasto.pl)

The models have been developed in the environment of the German VISUM software (PTV Systems 2000). They have been defined in the 2000 system applicable in Kujawsko-Pomorskie Province, zone 6, with the attributed definition of the system as ETRS_1989Poland_CS2000_Zone_6/GCS_ETRS_1989. This definition provides the correct functionality of the model in serving all map studies, including Google maps. In all models, the urban units and transport districts have been defined in the Province as POIs (Points of Interest).

The conducted analyses took account also of the general concept of developing the road system of Kujawsko-Pomorskie Province presented in the regional assembly in 2013.

Results of spatial traffic distribution analyses

Owing to the simulation traffic analyses carried out according to transport models, it has been possible to determine the following measures that characterise traffic conditions in the road network of the Province:

- traffic flow per average working day,
- road network load factors (which means the quotient of traffic flow on a road network element to the capacity of the element multiplied by 100%; traffic conditions on network elements where this value does not exceed 100% can be recognised as generally acceptable, because the lower the value is, the better; while in elements where X > 100% during rush hours, major traffic hindrance may be expected),
- transport activity carried out by vehicles during an average working day expressed in vehicle-kilometres (vkm),
- time spent in the network by all drivers and passengers of vehicles during an average working day expressed in vehicle-hours (vh).

Using the above data and the data available in (Jaspers 2008), the costs of traffic per day and year can be determined, including the operating costs of vehicles, time spent by drivers and passengers of vehicles in the road network while travelling and costs of environmental impact.

The simulation computing of traffic has been made for the following scenarios of the road network system in the Province:

- scenario with no investments (W0), and
- scenario with investments (W1), taking into account the operation of the dam in Nieszawa, for 2020, 2025, 2030, and 2035.

Examples of maps of forecast mid-day traffic flow obtained in computing using the simulation transport model for the investment scenario (W1) are presented in:

- Fig. 3 – for 2020,
- Fig. 4 – for 2035.

According to the analysis of data presented in the maps, the value of mid-day traffic flow will amount to almost 3.5 thousand vehicles in 2020, and about 1.0 thousand vehicles in 2035. This major fall in traffic flow (more than 70%) results from the construction of the S-10 express road in Kujawsko-Pomorskie Province. This new fast road, owing to its high technical standards, will take over a major part of traffic from the existing national and provincial roads.

Table 1 presents the forecast values of time spent on travels by drivers and passengers as well as the transport activity carried out in the whole road network of the Province on an average working day, for specific scenarios in 2020–2035. The results have been also obtained based on simulations, using the transport model for Kujawsko-Pomorskie Province.

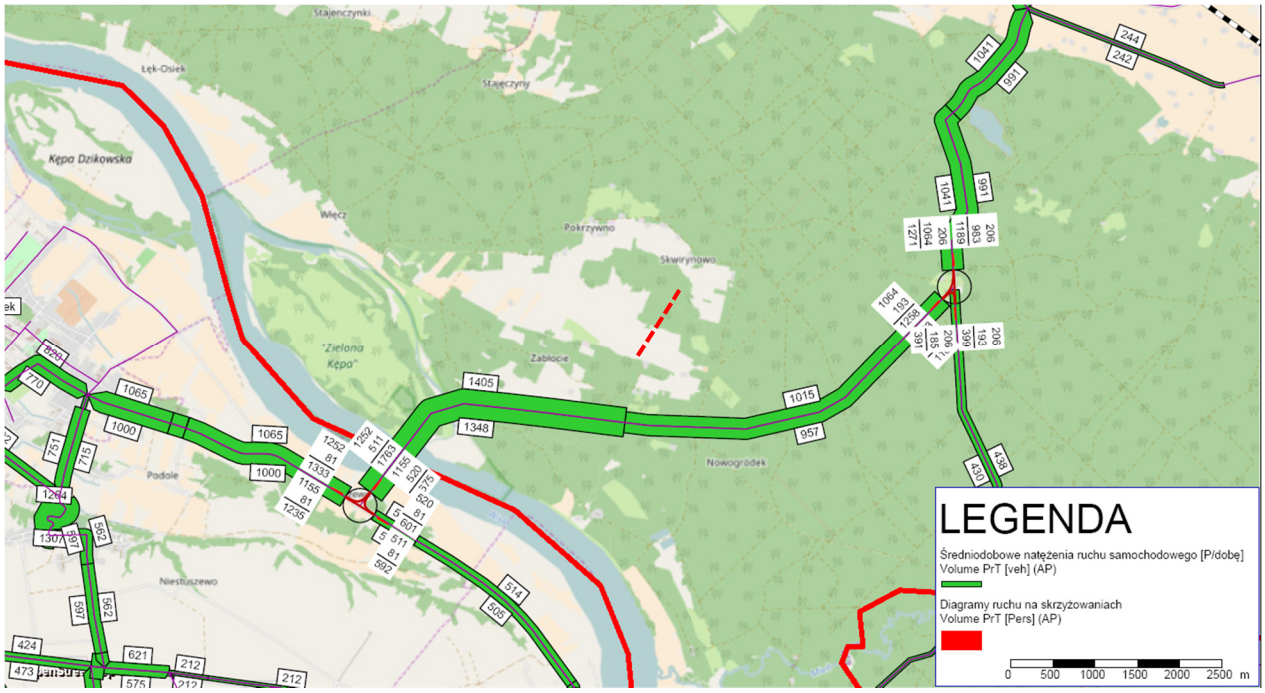

Fig. 3. The map of annual daily traffic for scenario W1, year of forecast 2020

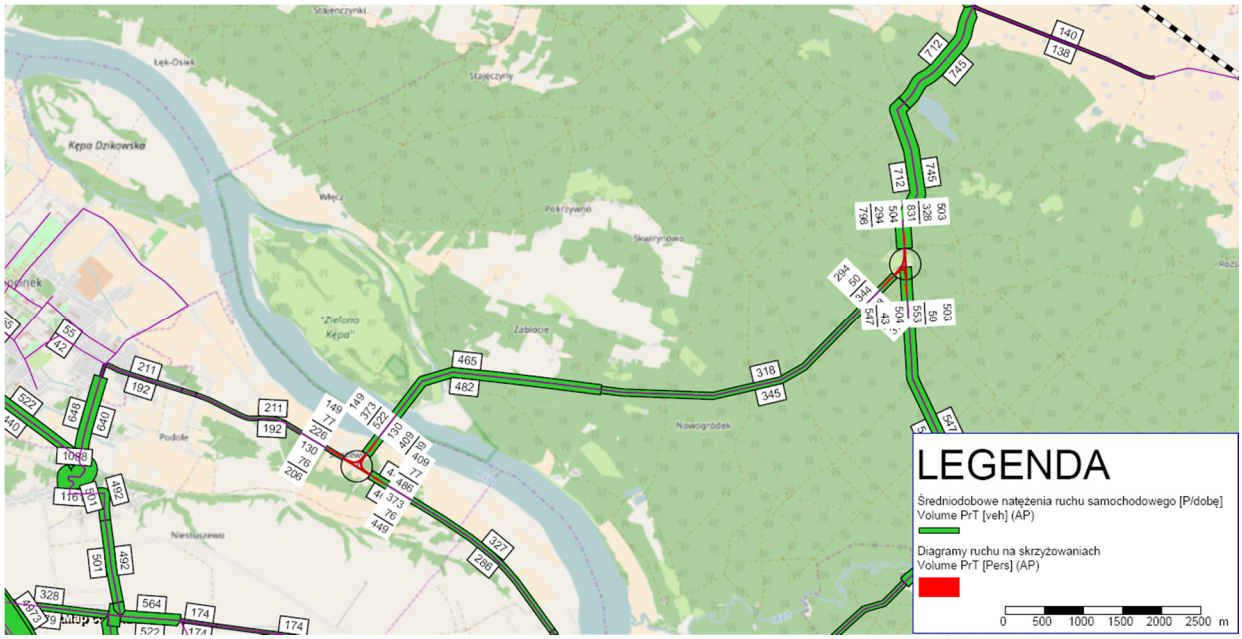

Fig. 4. The map of annual daily traffic for scenario W1, year of forecast 2035

Table 1. Values of time spent by drivers and passengers and the transport activity for specific scenarios for the analysed years of the forecast on an average working day

Means of transport	Time spent on travels [vh]		Transport activity [vkm]	
	Scenarios		Scenarios	
	WO	W1	WO	W1
Year 2020				
C	64.290	64.188	4.589.331	4.582.049
D	43.443	43.381	3.063.663	3.059.078
O	355.965	355.215	25.575.477	25.563.402
Total	463.698	462.784	33.228.471	33.204.529
Year 2025				
C	67.270	67.260	4.914.750	4.914.018
D	43.645	43.640	3.150.388	3.149.854
O	361.990	361.854	26.544.743	26.540.655
Total	472.904	472.753	34.609.880	34.604.527
Year 2030				
C	71.122	71.111	71.122	71.111
D	45.975	45.969	45.975	45.969
O	363.874	363.738	363.874	363.738
Total	480.970	480.818	480.970	480.818
Year 2035				
C	75.253	75.242	5.483.634	5.482.817
D	48.442	48.436	3.479.811	3.479.217
O	365.936	365.791	26.555.255	26.550.583
Total	489.631	489.469	35.518.700	35.512.617
C – trucks; D – vans; O – passenger cars				

The analysis of data from the table shows that the launch of the investment, namely the construction of the dam, would contribute to the shorter time spent on travels by drivers and passengers compared to the scenario with no investments in all forecast periods. The same situation occurs with respect to the transport work.

The further analyses involved the determination of savings in traffic costs that would be obtained owing to the construction of the analysed dam. Three elements have been taken into account in costs: time spent in the network by drivers and passengers, vehicle operation, and environmental impacts. The unit costs of user time, road infrastructure, vehicle operation, and environmental impact have been adopted according to (Jaspers 2008). The analysed costs per day and year for the scenarios without the investment (W0) and with the investment (W1) for 2020–2035 have been presented in Table 2. Table 3 presents the differences between the analysed costs between the scenarios with and without the investment.

Table 2. Daily and year traffic costs for particular scenarios and the forecast years [PLN million]

Scenario	Cost element	Transportation system			Sum per day	Sum per year
		C	D	O		
Year 2020						
WO	trip time	5 280.75	3 568.43	20 179.47	29 028.65	8 708 594.51
	vehicle operation	30 347.89	13 088.66	48 060.62	91 497.16	27 449 148.69
	environment	6 470.96	162.37	997.44	7 630.77	2 289 232.44
W1	trip time	5 272.44	3 563.29	20 136.97	28 972.70	8 691 808.81
	vehicle operation	30 299.73	13 069.07	48 037.93	91 406.73	27 422 018.36
	environment	6 460.69	162.13	996.97	7 619.79	2 285 937.94
Year 2025						
WO	trip time	6 338.15	4 112.24	23 667.12	34 117.51	10 235 253.15
	vehicle operation	36 757.26	15 222.31	56 416.58	108 396.15	32 518 844.65
	environment	6 929.80	166.97	1 035.24	8 132.01	2 439 603.95
W1	trip time	6 337.20	4 111.72	23 658.23	34 107.16	10 232 146.52
	vehicle operation	36 751.78	15 219.73	56 407.89	108 379.40	32 513 821.14
	environment	6 928.76	166.94	1 035.09	8 130.79	2 439 237.83
Year 2030						
WO	trip time	7 400.21	4 783.68	26 401.66	38 585.55	11 575 665.21
	vehicle operation	43 910.12	18 094.33	63 817.65	125 822.10	37 746 629.54
	environment	7 319.47	175.48	1 035.42	8 530.37	2 559 109.89
W1	trip time	7 399.11	4 783.08	26 391.81	38 574.00	11 572 199.19
	vehicle operation	43 903.59	18 090.98	63 810.26	125 804.83	37 741 448.67
	environment	7 318.38	175.45	1 035.30	8 529.13	2 558 737.68
Year 2035						
WO	trip time	8 413.34	5 415.78	28 664.89	42 494.01	12 748 203.36
	vehicle operation	52 510.98	21 528.42	72 263.44	146 302.83	43 890 849.24
	environment	7 731.92	184.43	1 035.65	8 952.01	2 685 602.82
W1	trip time	8 412.07	5 415.09	28 653.55	42 480.71	12 744 213.43
	vehicle operation	52 503.15	21 524.74	72 250.72	146 278.61	43 883 584.09
	environment	7 730,77	184,40	1 035,47	8 950,64	2 685 192,92
C – trucks; D – vans; O – passenger cars						

Table 3. Differences in traffic costs and environmental impact for the analysed scenarios [PLN million]

Year of forecast	Difference of costs (W0-W1)
2020	47.2
2025	8.5
2030	9.0
2035	11.7

According to the analysis of the above data, the construction of the dam with the road crossing is fully reasonable, considering the reduced costs of travel time, operating costs of vehicles, and environmental impact. During 15 years, the savings would amount to ~0.235 PLN billion.

Summary

The conducted simulation analysis of road traffic in Kujawsko-Pomorskie Province in view of constructing a dam across the Vistula in Siarzewo leads to the conclusion that the investment is reasonable taking into account the savings of costs in driver and passenger time, vehicle operation, and environmental impact. During 15 years, the savings would total about 0.235 PLN billion. Moreover, it has been indicated that the effects concern the first years after the launch of the investment project. The development of the road network contributes significantly to the reduced role of the analysed investment in the road network of the Province.

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