

# Present and Future Spatial Accessibility of the Polish Sea Ports

## Dostępność przestrzenna polskich portów morskich

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**Abstract:** Spatial accessibility is an increasingly popular indicator of assessing the level of development of transport infrastructure, and its impact on the development of particular territorial units. Among the most often used indexes of accessibility that can be applied to analyses prepared for the purposes of sea ports and coastal areas, are the following:

- ◆ time accessibility (presenting in a cartographic review how much time it takes to get to particular points), and accumulated accessibility;
- ◆ potential accessibility (presenting units positions on the background of general transportation network of a given mode).

The aim of this study was to assess the potential road accessibility in the years 2015 and 2030, as well as the changes resulting from the investments planned for this period of time. In the study of accessibility to the network of the existing sea ports, there were taken into account: Elbląg, Gdańsk, Gdynia, Ustka, Darłowo, Kołobrzeg, Świnoujście, Police and Szczecin. Analyses of these ports' time accessibility have been also performed.

It has been established that none of the Polish ports can boast of sufficient road connections with important national centres, which are their vital economic hinterland. The situation in Tricity (Gdańsk, Sopot, Gdynia) is most favourable, and its further improvement depends on completion of the S5 and S7 express roads, and on the implementation of investments within the agglomeration. Extending the Szczecin Lagoon ports' hinterland is going to be more problematic though it will also take place after the S3 road is completed. The small ports on the central coast are accessible by the system of roads only to a very limited degree and are not likely to improve their situation in the years to come. Implementation of the S6 express road will alter this state only partially (because of it running latitudinally). An integrated, spatially big market can be found only in the Tricity region. No integration of this kind can be found in the Szczecin-Świnoujście complex, not to mention the central part of the coast. The planned investments are to increase the range of the Tricity metropolis's employment market (e.g. by Elbląg), and will allow an integration of the market within the area of the Szczecin Lagoon.

**Keywords:** sea ports, accessibility, road transportation.

**Streszczenie:** Dostępność przestrzenna jest coraz częściej stosowaną miarą pozwalającą na ocenę poziomu rozbudowy infrastruktury transportowej oraz jej wpływu na rozwój określonych jednostek terytorialnych. Do najczęściej stosowanych miar dostępności, które mogą mieć zastosowanie w przypadku analiz na potrzeby portów morskich oraz obszarów nadmorskich, należą:

- ◆ dostępność czasowa (pokazująca w ujęciu kartograficznym czasy dojazdu do określonych punktów) oraz skumulowana;
- ◆ dostępność potencjałowa (pokazująca pozycje jednostek w ogólnej sieci transportowej danej gałęzi).

Celem opracowania była ocena dostępności potencjałowej drogowej w roku 2015 i 2030 oraz zmian w wyniku inwestycji planowanych w tym okresie. W badaniach dostępności do sieci istniejących portów morskich uwzględniono: Elbląg, Gdańsk, Gdynia, Ustka, Darłowo, Kołobrzeg, Świnoujście, Police i Szczecin. Dla tych portów wykonano także analizy dostępności czasowej.

Stwierdzono, że polskie porty mają nadal niewystarczający poziom powiązania drogowego z ważnymi ośrodkami krajowymi, stanowiącymi ich istotne zaplecze gospodarcze. Najlepsza sytuacja występuje w Trójmieście, a jej dalsza poprawa zależy od realizacji dróg ekspresowych S5 i S7 oraz od inwestycji wewnątrzaglomeracyjnych. Powiększenie zaplecza portów rejonu Zalewu Szczecińskiego jest trudniejsze, ale również powinno mieć miejsce w przypadku ukończenia budowy drogi ekspresowej S3. Małe porty wybrzeża środkowego są bardzo słabo dostępne w systemie drogowym i nie poprawią tej sytuacji w najbliższych latach. Budowa drogi ekspresowej S6 tylko częściowo zmieni ten stan rzeczy (z uwagi na równoleżnikowy przebieg). Zintegrowany przestrzennie duży rynek istnieje tylko w rejonie Trójmiasta. Brak jest takiej integracji w zespole Szczecin-Świnoujście oraz tym bardziej, na wybrzeżu środkowym. Planowane inwestycje zwiększą zasięg rynku pracy metropolii Trójmiasta (m.in. o Elbląg) oraz pozwolą na integrację rynku w rejonie Zalewu Szczecińskiego.

**Słowa kluczowe** porty morskie, dostępność, transport drogowy

## Introduction

Spatial accessibility is gaining popularity as an indicator allowing for assessment of transportation infrastructure's level of development, and its impact on the development of particular territorial units (including specific cities and towns) or objects (e.g. sea ports). Replacing the traditional indexes (such as length and density of the network, and the geographical distance) occurs especially in case of the evaluation studies conducted at the European, as well as the national level, and recently, also at the regional one. References to the accessibility indexes can be found in the European documents such as the Territorial Agenda of the European Union 2020, and the Cohesion Reports, as well as in the national documents (including the National Spatial Development Concept 2030). Devoted to this issue was also a separate big research project of the ESPON Programme (the ESPON TRACC project), an element of which were the analyses of accessibility in the global transport (the container traffic included), as well as studies of sea ports' hinterland. At the brink of gaining a new EU financial perspective, the indexes of accessibility were accepted as the result indicators in most of the voivodeships and applied in the assessment of the Regional Operational Programmes' effects. In the 2014-2015, the Ministry of Infrastructure and Development commissioned the Institute of Geography and Spatial Organisation of the Polish Academy of Sciences to conduct a project, the aim of which was further modernisation of the indexes of spatial accessibility as used in Poland, especially the Multi-modal Transport Accessibility Index (WMDTII).

Among the most often used indexes of accessibility that may be applied to analyses conducted for the purposes of the sea ports and coastal areas are the following:

- ◆ time accessibility (presenting in a cartographic review how much time it takes to get to particular points by means of road or railway transport in compliance with specific models of traffic), and accumulated accessibility (which makes it possible to estimate the number of population and other characteristics within the specific isochrones);
- ◆ potential accessibility (presenting units positions on the background of general transportation network of a given mode, while taking into account the significance/mass of the units under scrutiny; in Poland these are mostly municipalities, and at the European level – the NUTS3 units [8]); the potential accessibility is calculated in the matrix form, taking into account the relations between each pair of the units under investigation.

There is a variety of other approaches to accessibility (for the overview see [4]; [8]). However, the potential model is the most widely used to express the effects of transport investments [18] or programmes [5] on accessibility improvement [15]. The time accessibility was used in Poland, among others to create the ranking of road and rail investment in National Spatial Development Concept 2030 [12, 11, 13, 12, 9]

Accessibility studies may be useful while determining the competitive position of the sea ports in relations to other similar ob-

jects by means of presenting the coverage of their natural hinterland, a precise specification of the market's significance (e.g. its GDP, number of companies, number of the population or tourists within a given isochrone, that is a line of equal travel time it takes to get to the port). They also allow determination of a territorial unit's position in the transportation system of the country or Europe, as well as serve as a tool for assessing what part of the particular transport routes, especially the newly implemented investments, play in the improvement of the unit's (or port's) position in the transport system. Analyses performed for the ports and coastal zones may just as well be correct interpretations of the already gathered materials (the previous projects' results), as they may constitute an entirely new dedicated research. When various indexes and boundary values (e.g. isochrones in time accessibility) are employed, it is possible to determine the current as well as the anticipated position of an administrative unit in relation to the local labour market, and tourist traffic generators.

The scope of this study encompasses a reinterpretation of chosen earlier evaluation studies and other accessibility analyses made at the European and national levels and concentrated on the multi-modal accessibility of the sea ports (with the passenger and goods transport set apart). Analyses of the potential accessibility by roads in the years 2015 and 2030, and of the changes occurring because of the investments planned for this period have been conducted. Separately, there has been performed a simulation of changes in the potential accessibility due to implementation of the S6 express road and the metropolitan Tricity metropolis ring road, and later also an analysis of the time accessibility by roads has been prepared for the network of chosen ports. The choice of routes to be subjected to the simulation was dependent on the feasibility of the investment plans of the General Directorate for National Roads and Motorways (GDDKiA). According to the Transport Development Strategy 2020 implementation document, in the next financial perspective on the area under investigation and its vicinity, there are planned the following investments in the road sector:

- ◆ completion of sections of the S7 express road in the Warmińsko-mazurskie Voivodeship (including the Gdańsk-Elbląg section);
- ◆ implementation of the S6 express road from Gdańsk (together with the planned new metropolis ring road) through Słupsk, Koszalin, Kołobrzeg to Szczecin;
- ◆ implementation of the S3 express road between Szczecin and Świnoujście;
- ◆ implementation of the S5 express road between Grudziądz, Bydgoszcz and Poznań.

In the studies of accessibility to the network of existing sea ports, there were taken into account the following ones: Elbląg, Gdańsk, Gdynia, Ustka, Darłowo, Kołobrzeg, Świnoujście, Police and Szczecin. Ports in Darłowo, Ustka and Kołobrzeg not currently support larger cargo traffic. They perform local functions (including fishing and tourism). In the analysis, they were taken into account in the context of the demands of the possible building of new ports on the Polish coast central section.

Analyses of these ports' time accessibility in the year 2015, and in 2030 have been performed, and then also analyses of the accumulated accessibility (population, economic operators and tourist facilities) by the road transport. On this basis, there has been made in the conclusions section an overall interpretation of the entire material in relation to the plans for the development of the sea ports, and forms of use of the marine space. There have been also included recommendations for the spatial planning policy and investment activities.

When it comes to Świnoujście, the place for which the calculations have been performed (the port's location) was the ferry terminal on the Świna River's eastern bank. Because of this, the analysis did not cover the lack and possible implementation of a fixed passage between Wolin and Uznam Islands. For the purposes of the analyses for the year 2030, assumptions were made that till then there will be completed all the investments enlisted in the National Spatial Development Concept (KPZK) 2030 [12], and in the Programme for the Construction of National Roads. And so, it means that on the area subjected to the analysis there will exist the S3, S6, S7, S10, S11 express roads in their full length, as well as the new Tricity ring road (so-called metropolis ring road).

Calculations of the potential accessibility ( $A_i$ ) were made in relation to the number of population (population was the "mass" -  $M$  - of each of the units), and basing on the assumption that a travel is to be of an average length described by a relatively gently curved space resistance function with the following formula:

$$A_i = M_i \exp(-\beta t_{ii}) + \sum_j M_j \exp(-\beta t_{ij})$$

Where:  $M_i \exp(-\beta t_{ii})$  is municipality's own potential,  $t$  is the time it takes to travel between the  $M_i$  and  $M_j$  municipalities, and the beta parameter equals 0.013862 (which corresponds to a situation, where the travel destination's attractiveness halves when the estimated travel time reaches 50 minutes). The study covered only the territory of Poland and do not take into account the "masses" located outside its borders (such as destinations in Germany or Russia, which might have impacts of accessibility potential of Szczecin (German destinations) and Elbląg (Kaliningrad). More specifically methodology was described in papers related to the road projects evaluation [7, 8, 15]

Data on population numbers, companies, and hotel beds were not forecasted (to isolate the effects of the upgrading of the road infrastructures). The latest available CSO data was used on the assumption that they remain constant in time.

A road traffic model prepared in the Institute of Geography and Spatial Organisation (identical with the one used in surveys conducted for the Ministry of Infrastructure and Development) was used. The model, starting from the maximum speed limits for each category of roads as shown in the highway code, assumes the speeds may be reduced due to:

- ◆ the road's crossing a built-up area (determined on the basis of satellite images);

- ◆ number of the population within the distance of 5 km from the road (assumption of it's being proportionate to the congestion and traffic disruptions connected with traffic organization, e.g. the traffic lights);
- ◆ land downslopes (diversified relief of an area).

On the coastal area of our focus, the influence of the population density was very clear in the region of Tricity and Szczecin, and to a lesser degree, also Koszalin, Słupsk and Elbląg. The impact of being situated within a built-up area could be additionally observed by some of the roads running along the coast in the tourist areas (such as the neighbourhood of Kołobrzeg). The land slopes play a noticeable part in the regions of Central Pomerania, and Elbląg Uplands. The calculated speed limitations are not subject to summing up. In accordance with the weakest link rule, the final speed is the lowest one of three speeds calculated in relation to each of the limiting elements.

- ◆ The presented results are not the feasibility studies for specific investments in seaports, nor road investments. Their purpose is merely to show the expected effect of the development of the road network on the position of the Polish ports in the socio-economic space, especially in terms of:
  - ◆ the economic base of the ports;
  - ◆ the impact of ports on the labor market;
  - ◆ tourism development.

### 1. Polish ports in the light of the earlier European and national accessibility studies

Studies of the potential accessibility on the European scale have been conducted for several years already, mainly by the German teams [16], and also for purposes of the ESPON (mainly ESPON TRACC) projects [2, 17]. Besides in some countries of Central-East Europe (e.g. Poland and Slovakia) trans-border analysis were prepared based on the similar indicators (Więckowski i in.).

The results obtained due to the ESPON TRACC [2] project direct our attention to the clear diversification of the European areas in terms of global accessibility. To provide a picture of this issue, both the potential, and the travel-cost (isochrones) accessibility indexes were used. Researches have been made on accessibility to centres in the North America and the Asian Far East (China, Japan). Their results revealed a polarity, which in relation to transport of goods was one of geographical dimension (the Atlantic, and even the Baltic regions were characterised by a good access to destinations in North America, while the Mediterranean regions, thanks to the Suez Canal, had a relatively better access to regions of East Asia). In case of the passenger transport, the polarity corresponded rather to a centre-periphery pattern. It turned out to occur both at the European level (there are more intercontinental airports within the co-called European Pentagon), and the national one (connections of this type are concentrated in the airports which provide services to capital cities [2]).

The global potential accessibility to container terminals for transport by rail illustrates the position of Polish sub-regions in

relation to such objects. The prominence of the part that Tricity terminals play was not made clear, as the ESPON projects were based on the data from before these terminals' spectacular development. Nonetheless, the relatively good position of the Western Poland regions, which is a result of good access to the Atlantic terminals through the German infrastructure should be emphasized. What also calls for attention, is the very low index level observed on the central coast. However, it should be treated not so much as an index of lack of container ports, but rather as a measure of poor linkage with Polish and foreign ports through railway infrastructure (higher notes of the index are observed e.g. in Warsaw, and even in the corridor to the east of the capital city, leading to the border with Belarus).

In the evaluation study of the motorways and express roads built with the European Union's support in the years 2004-2015 [7], there were separately analysed changes of the potential accessibility at the national level (where only the destinations within the Polish borders were included), and the international level (destinations in the entire Europe). The proven improvement of the national accessibility was relating to the entire Northern Poland region to a very limited degree, which results from the fact that the primary investment's (the A1 motorway) Northern section was built within a concession-based system. Effects of the EU's support could only be seen in the western parts of the region (resulting from the implementation of the S3 express road), and near the border with Russia (road no S22). A different picture was obtained while assessing the accessibility at international level. Here, the region that clearly benefited was the eastern part of the coastal zone (with the Tricity). It is a result of reducing the travel time to German territories (through the investments on the A2 motorway and S8 road), and to Czechia, which were also easily accessible by the concurrently under construction A1 motorway, which was not included in the study. This result proves the significance of synergy of investments implemented with support from different sources. Taking into account the fact that international accessibility is contingent upon parallel investments, the lack of improvement on the Zachodniopomorskie region seems to be related to refrain from the investments within the S6 road.

What is also worth noticing, is the assessment of changes of accessibility with use of the Beta convergence ratio (for the 1995-2015 period, with an assumption that all the road investments initiated within the 2007-2013, financial perspective are completed). It shows voivodeships as losers, winners, and ones catching up in terms of the external accessibility level. From among the coastal voivodeships, the Pomorskie Voivodeship is listed among the catching up ones (a high increase of the index combined with a low initial level). At the same time, the Zachodniopomorskie Voivodeship, as the only one from outside the Eastern Poland, remains in the group of losers (a low increase, and a low initial level). In this group, there is also the Warmińsko-mazurskie Voivodeship. It proves the theory that the main investment improving the overall accessibility of the region is the A1 motorway. To complete the analysis of the year 2015, it can be assumed that there occurred an internal polarization of the area in question in terms of spatial accessibility. However, the temporal increases of polar-

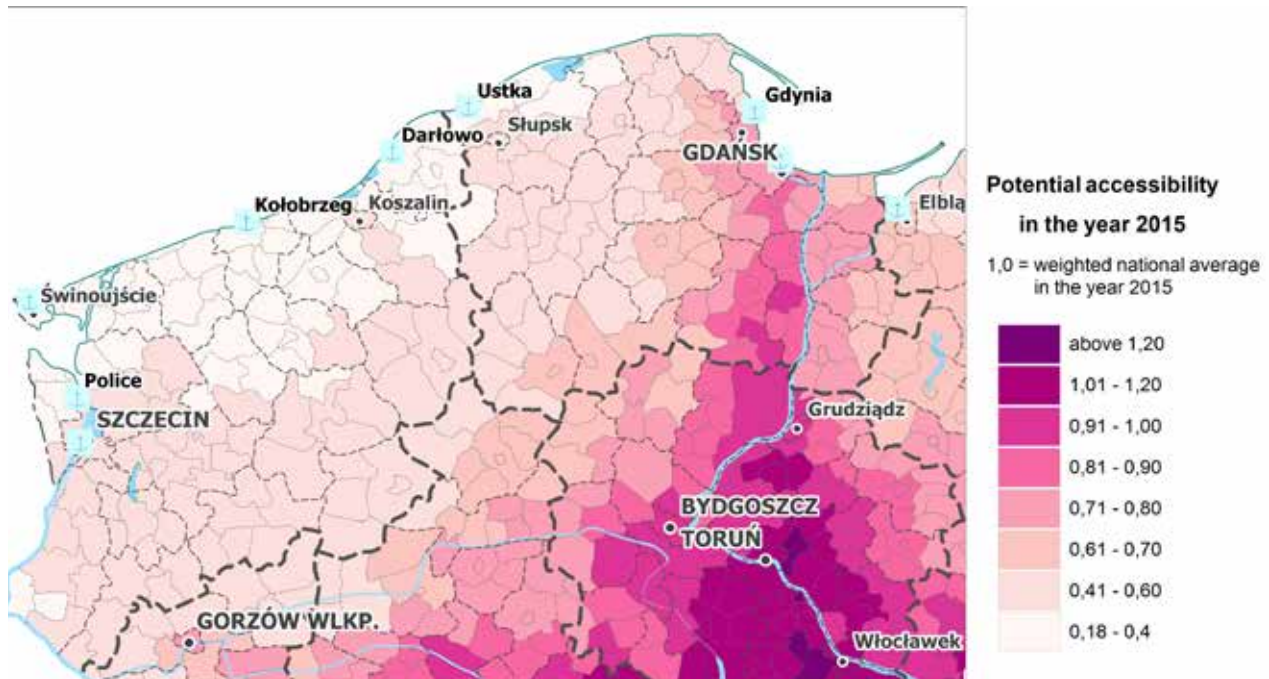
ization indexes are an unavoidable effect of every wide-ranging investment process.

Polish sea ports development is strictly dependent on their hinterlands, and thus, the accessibility in land transport. Polish port hinterland has changed in the transition period and after accession to the EU. The transport system (including development plans - a priority for routes A1 and S3) was, and to some extent remains, adapted to the former situation (heavy industry, including mining in the south of the country, the transit from the countries in the south of Polish). Modern linkages analysis (including exports) proved [6] that important ports relationships are sliding and support major Polish metropolises (especially Warsaw, Poznan and Wrocław). At the same time, it increased the role of the interactions between the states of the Baltic Sea region (also with regard to the Middle Pomerania [1, 2]).

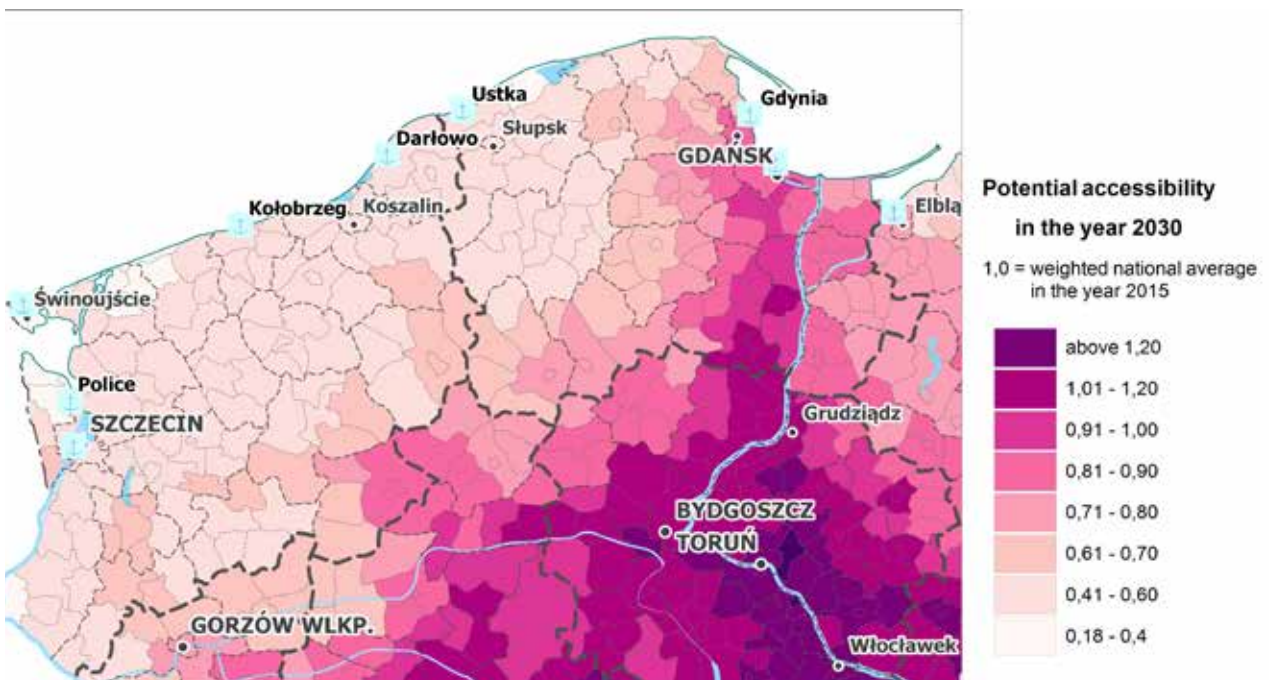
## 2. Changes of potential accessibility in the coastal zone

Spatial distribution of potential accessibility by roads in the year 2015 (calculated as a domestic weighted average; see Figure 1/Rycina 1) is characterized by a strong impact of the new investment (the A1) on the index values in the eastern part of the analysed area. The further south-east from the conventional line connecting Gdańsk and Gorzów Wielkopolski, the more the accessibility gradually decreases. Despite this, the accessibility index exceeds the domestic average nowhere in the Pomorskie and Zachodniopomorskie Voivodeships, and it only gets close to the limit in the strip of land in direct neighbourhood of the A1 motorway between Grudziądz and Gdańsk. The strong impact of the new road ceases in Tricity, and the index diminishes in a stepwise manner to the north of Gdynia in the region of a high tourism penetration ratio. In case of the Zachodniopomorskie Voivodeship, despite an improvement of access to Szczecin, on its entire northern part there are observed very low values of the index. From among the port-cities, a comparatively higher accessibility at the national level can be attributed to Gdańsk and Gdynia, and subsequently, to Elbląg (compare with Table 1/Tabela 1). A particularly low level of the index can be noticed in Świnoujście and Police while in Ustka, Darłowo and Kołobrzeg it is not much higher. The index values increase with moving further east, which is due to their dependence on the A1 motorway leading to Tricity.

Should all the investments listed in the National Spatial Development Concept (KPZK) 2030 be completed, changes of potential accessibility in the region under analysis will be substantial. In the map (Figure 2/Rycina 2), there is a visible layout of municipalities corresponding with the routes of the planned investments such as the S6, S10 and S11 roads. The lowest values of the index persist in the north-eastern part of the seaside. The accessibility ranking of the ports under analysis is resistant to any significant reshuffling. Thanks to the routes of the S11 and S6 roads, Kołobrzeg, and to a lesser degree also Darłowo are to advance higher in the ranking. In the southern part of the Pomorskie Voivodeship, there occur municipalities, the level of accessibility of which is higher than the domestic average. The general spatial arrangement, however,



Ryc. 1: The level of potential accessibility in the coastal zone in the year 2015. Source: Own elaboration, M. Stępnik

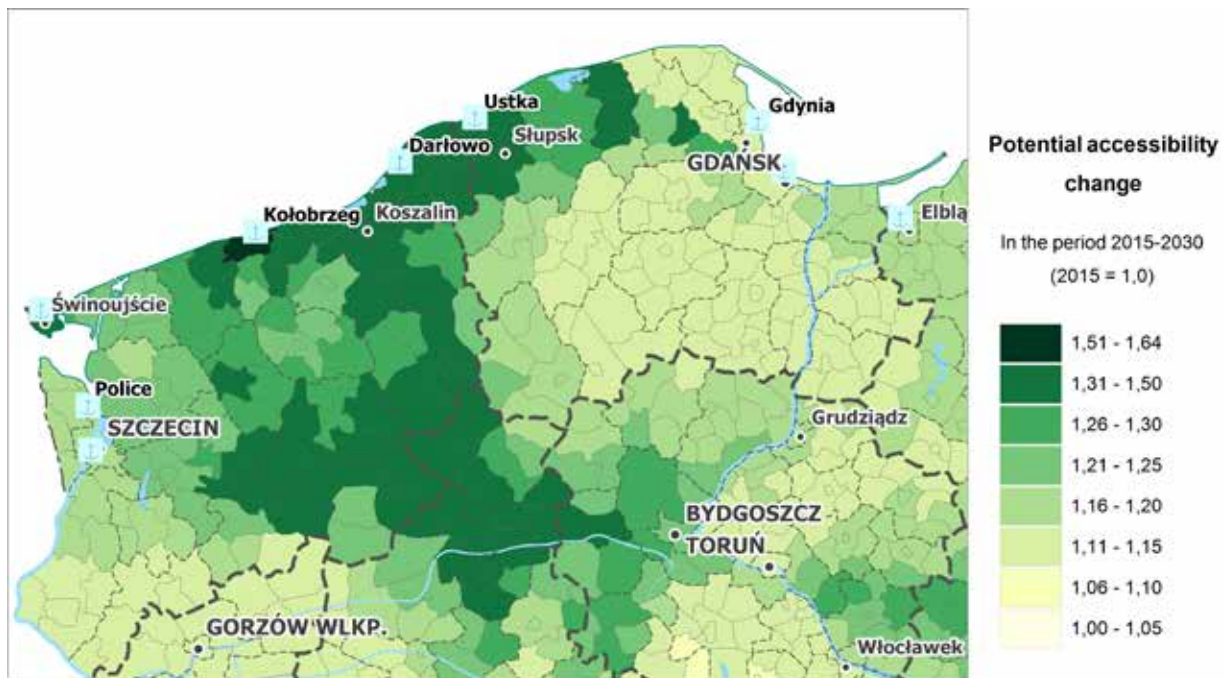


Ryc. 2: The level of potential accessibility in the coastal zone in the year 2030 (a simulation). Source: Own elaboration, M. Stępnik

remains stable. Line dividing areas characterized by the lowest values is only moving further to the north-east, and its route got disturbed with stripes of a better accessibility running along some of the new express roads. Analysis of both of the spatial arrangements (2015 and 2030) proves that a decisive factor in the domestic (internal) accessibility of the coastal area are connections with the main metropolitan centres of the central and southern Poland, including Warsaw and Poznań.

Rycina 3). The highest increments of the index can be observed on the Central Coast, and they are relative to the possible S10 and S11 roads, which provide connections with the capital city and the Wielkopolskie. Impact of the S6 express road's implementation is also visible, especially in the Pomorskie Voivodeship (as an extension of accessibility conditioned by the A1), but it is of a limited reach concentrated in the units situated by the route. It can be observed most clearly in case of the north-eastern municipalities of the Pomorskie Voivodeship (the entire tourist region of the Puck county), where accessibility level remained almost unchanged. It is a result of the layout of the so-

What further proves it, is the territorial composition of percentage changes in accessibility in the 2015-2030 period (Figure 3/



Ryc. 3. The anticipated improvement of the accessibility index in the years 2015-2030. Source: Own elaboration, M. Stępnik

called Kashubian Route (*Trasa Kaszubska*) located to the south of the present Gdynia-Wejherowo urbanised zone, which all in all does not help solve the problem of congestion occurring there (and escalating especially during the tourist season).

Levels of percentage increase for the cities/ports under analysis have been tabulated in Table I/*Tabela I*. At the national level, the improvement of accessibility by roads resulting from completion of all the investments listed in the National Spatial Development Concept 2030 is equal almost 17%. The situation varies in the cities/ports in question. Its improvement in Gdańsk and Gdynia is below the domestic average, while in Szczecin, Elbląg and Police it got close to the level. Things look much better in Świnoujście and ports of the central coast. The unit where accessibility is improving best (on the background of the entire coastal zone) is Kołobrzeg (improvement by over 52%). The situation is getting better also in Darłowo and Ustka. At the same time, spatial arrangement is being reversed (in relation to the situation from 2015). On the central coast, higher notes of the index can be observed in the ports situated further to the west. Thus, the area is no longer dependent on the A1 motorway. A city that also benefits a lot is Świnoujście. At the same time, assessments of high increases of the potential accessibility on the west and central coast should be interpreted with caution, as to some degree, they result from the so-called low base effect (a poor initial accessibility).

The obtained result may be treated as a location factor for a possible new port infrastructure, including e.g. a ferry terminal. Using potential accessibility factor as means of measuring communication with hinterland of the possible ports on the central coast, it can be said that after 2030, the best level of communication will be in Kołobrzeg, and it will decrease further to the east (worse situation respectively in Darłowo and Ustka). However, it can also be

claimed that the situation will be just the opposite, and possible initiation of investments on the route of the S11 express road from Poznań to Piła and Koszalin to Kołobrzeg, should be considered only parallel with the Kołobrzeg port's development plans.

### 2.1. Simulation of the chosen investments' results

What should in reality be taken into consideration, as the most probable options, are the investment plans included in the Implementation Document of the Transport Development Strategy 2020; especially the plans tenders for which have already been invited or ones being prepared. They are all investments which can be claimed to be completed within the next 10-15 years, and to help shape the market situation of the Polish ports. That is why a decision was made to prepare separate simulations of effects of the S6 express road's completion (Figure 4/*Rycina 4*; in the year 2014 tenders were invited for implementation of this investment from Goleniów through Kołobrzeg to Koszalin), and of the Tricity metropolis ring road (Figure 5/*Rycina 5*).

Accessibility's improvement due to the S6 road's completion is high in the Pomorskie Voivodeship, though spatially limited. In Tricity's vicinity, it encompasses only three municipalities neighbouring with the route. Further to the west it widens, but at the same time weakens in the Zachodniopomorskie Voivodeship. The spatial imaging shows that what may have a stronger pro-developmental effect, is implementation of the road's eastern section (from Tricity to Koszalin), while preparations for the investment have started at its western end (the tenders in the summer of 2014). The strongest accessibility effect occurs in the strip of land from Lębork to Koszalin, and then in the region of Kołobrzeg. High increases noticed in the latter city are related to the new (in comparison with the present national road) route of the S6 road, and bringing it nearer the coast. From among the port-cities, a high

Tab. 1. The anticipated changes of potential accessibility of chosen ports in the years 2015-2030

PORTS	POTENTIAL ACCESSIBILITY				
	2015 (ABSOLUTE VALUE)	2030 (ABSOLUTE VALUE)	2015 (POLAND=100)	2030 (POLAND =100)	CHANGE (2015=100%)
Darłowo	1093600	1471200	32,2	37,1	134.53
Elbląg	2188400	2573700	64,5	64,9	117.61
Gdańsk	2583900	2920400	76,1	73,7	113.02
Gdynia	2465000	2796600	72,6	70,5	113.45
Kołobrzeg	1087100	1656400	32,0	41,8	152.37
Police	1051900	1221700	31,0	30,8	116.14
Szczecin	1563700	1833200	46,1	46,2	117.23
Świnoujście	904260	1222100	26,6	30,8	135.15
Ustka	1118300	1456500	33,0	36,7	130.24
POLAND	3393362	3964947	100,0	100,0	116.84

increase of the index occurs also in Łeba. Comparatively much is gained also by Ustka and Darłowo. Among the cities situated in the coast's hinterland, Słupsk and Lębork are the greatest beneficiaries, and Koszalin takes the third position. There remains the identified earlier area situated to the north of Tricity which does not gain clear profits from the investment. The investment's impact lessens relatively fast also with moving southwards, and it does not encompass the southern borderlands of the Pomorskie and Zachodniopomorskie Voivodeships.

The results of building the new express ring road for the Tricity are quite limited. The percentage increases rarely exceed 2%. The most visible effect occurs in the municipalities situated directly to the North of Gdansk (the Kartuzy County). To a small degree, a beneficiary is again the region of Słupsk, and from among the seaports – only Ustka. Just as in the previous case, the investment does not impact anyhow the potential accessibility of the Northern parts of the Pomorskie Voivodeship (from Hel up to Łeba).

Comparing effects of the selected investments with effects that completion of all the investments listed in the National Spatial Development Concept 2030 would have, it must be emphasized that the recorded earlier rapid improvement of accessibility of Kołobrzeg (and Ustka) is more an effect of the S11 express road's implementation, rather than the S6 route's.

To sum up, the surveys of potential accessibility reveal the current peripheral location of the area in question against the background of the country (with the exception of the spatially limited Tricity neighbourhood). At the same time, changing the state of affairs depends most of all on the investments connecting the coast with the central Poland, and only secondarily, on the latitudinal investments. In the latter case, route of a road, and specifically its distance from the coastline, seaports and tourist resorts plays a vital role.

### 3. Time accessibility in relation to ports in the network

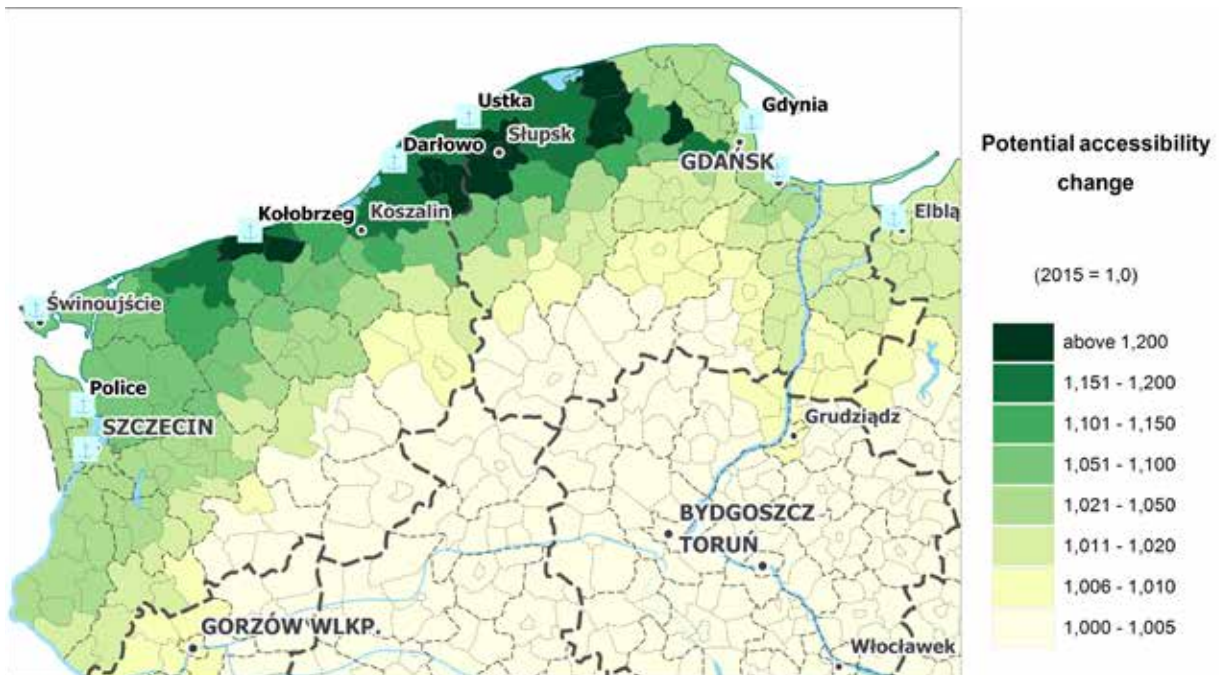
While analysing time accessibility in relation to the network of ports (Figure 6/Rycina 6), it was assumed that they are all of equal

significance. The arrangement of isochrones from 2015 is strongly determined by the existing at present road infrastructure, which translates into their having a comparatively wide reach Southwards along the A1 motorway (access to Gdańsk and Gdynia), S3 express road (to Szczecin, Police and Świnoujście), and the already completed parts of the S7 express road (Elbląg). At the same time, the relatively good accessibility of the ports in Ustka is much more territorially-limited, which is due to the lack of modern road infrastructure on the Central Coast. Areas characterised by a very good accessibility (below 30 minutes) form two tight zones:

- ◆ Szczecin – Police
- ◆ Gdynia - Gdańsk - Elbląg

Corresponding zones surrounding the other ports (including ones in Świnoujście) are smaller and spatially separated. The isochrone of 60 minutes, referring to the labour market, encompasses almost entire coastal zone. This means that it is possible for the workers of the seaports and port industries to commute from this zone. In the direct coastal area, there are exceptions to the rule – the zone between Ustka and Białogóra, and the tips of the Hel Peninsula and the Vistula Spit. At the same time, due to the already mentioned new infrastructure (motorways, express roads), it is possible, in theory, to commute and work in maritime affairs sector for citizens of such seemingly remote towns as Gorzów Wielkopolski (commuting to Szczecin), Grudziądz (to Gdańsk) and Ostróda (to Elbląg). The wide coverage of the 60 minutes isochrone in the Warmińsko-mazurskie Voivodeship is also resulting from the S22 express road running to the border with the Kaliningrad Oblast of the Russian Federation.

If all the road investments stated in the National Spatial Development Concept (KPZK) 2030 (the current maximum plan relating thereto), the arrangement of isochrones will not undergo very spectacular changes (Figure 7/Rycina 7), especially not in the Eastern part of the coastal zone. An improvement will take place in the sparsely populated areas of the Central Coast (to the south of Koszalin – resulting from the possible implementation of the S11 express road), and between Szczecin and Świnoujście (areas characterized by a good accessibility to both of the centres will



Ryc. 4. Improvement of the potential accessibility due to the implementation of the S6 express road. Source: Own elaboration, M. Stepniak



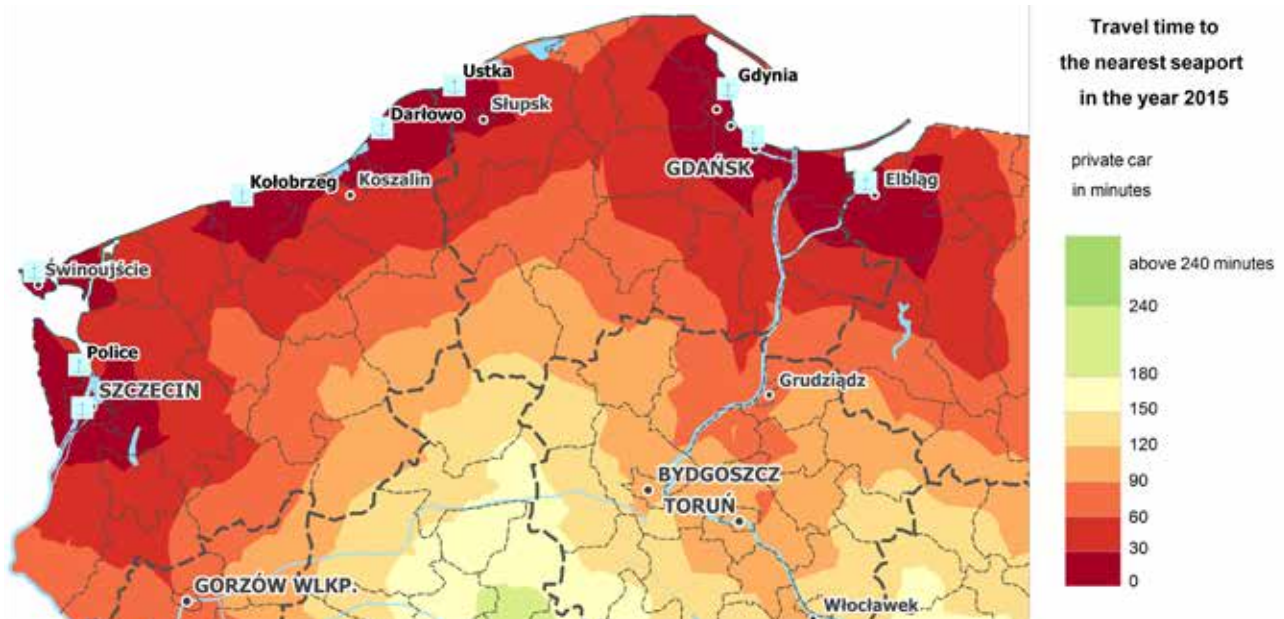
Ryc. 5. Improvement of the potential accessibility due to the implementation of the new Tricity metropolis ring road. Source: Own elaboration, M. Stepniak

be brought nearer to each other, but will not merge). An improvement is to occur also in the strip of land to the east of Szczecin (the S10 express road). It is peculiar that the implementation of the S6 express road along the coastline has a moderate impact on the arrangement of the isochrones. It's being a rocade road does not bring a significant increase of the labour markets connected with seaports in Kołobrzeg and Ustka. Also, the unfavourable situation of the strips of coast between Łeba and Białogóra, as well as of the sites remains unaffected by the new investments. The isochrones

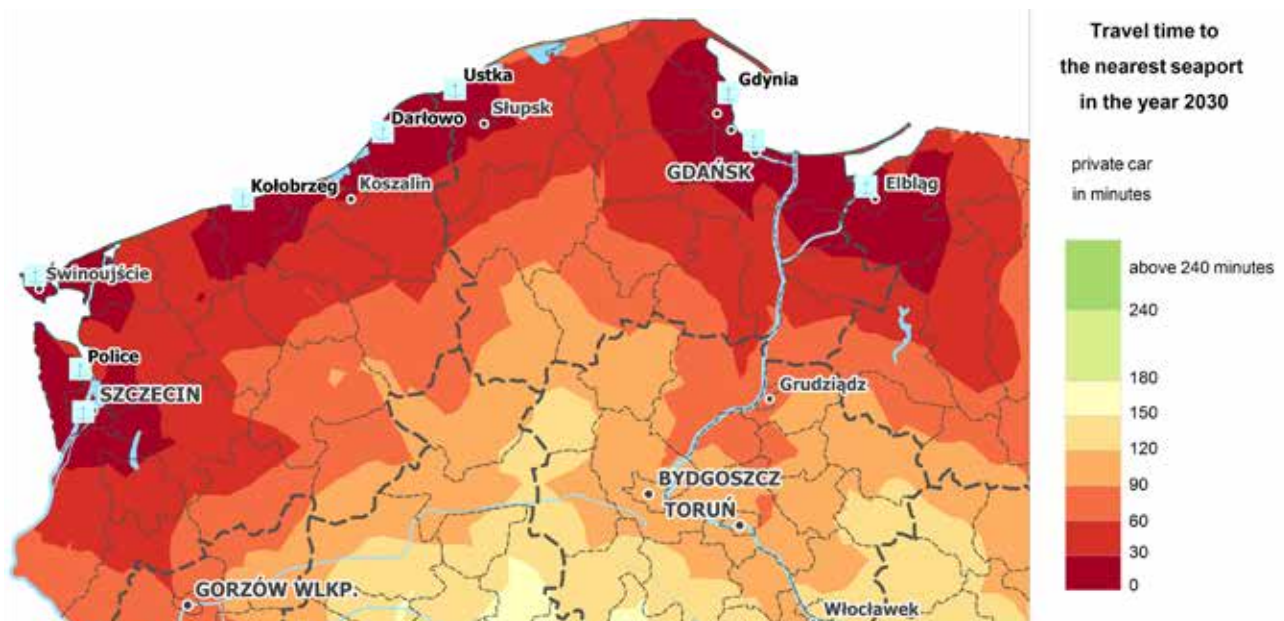
of 60 minutes travel time will also not encompass almost all of the big centres that might serve a role of hinterlands providing the workforce for the maritime affairs. It is not without significance, if we take into consideration the demographic projections, aging of the population and plausible in the 2030 shortage of workers at the ports as well as in the tourism sector.

For the wide hinterland of the defined earlier network of ports, curve of accumulated accessibility to the population takes the





Ryc. 6. Travel time it takes to reach the network of sea ports in the year 2015. Source: Own elaboration, M. Stępnik



Ryc. 7. Travel time necessary to reach the network of sea ports as in the year 2030 (a simulation). Source: Own elaboration, M. Stępnik

shape of letter “S” (Figure 8/Rycina 8). Within the isochrones of 240 minutes, the shape is more or less linear. It’s peculiar that the curves for the year 2015 and 2030 become different only outside the isochrone of 90 minutes. This means that the planned investments are of no great importance from the point of view of the maritime labour market. The greatest discrepancies occur in the 240–360 minutes travel time range, which is a sign of improvement of accessibility in the central Poland, and should be interpreted as an increased hinterland of the medium-stay tourism.

Corresponding layouts of the accumulated accessibility in relation to economic operators (based on the REGON register database) are a bit different (Figure 9/Rycina 9). We can observe a clear break of the curve around the isochrone of 150 minutes,

which means that the important concentrations of economic activity are located in its vicinity. Also, effects of the new infrastructure (in the 2030 perspective) are greater in the zone of 150–240 minutes travel time. It might result, among others, from a comparatively higher level of economic activity on the rural areas of the Northern Poland, which will get closer to the analysed network of ports in case the S10 and S11 express roads are built.

When it comes to the accessibility of hotel beds (Figure 10/Rycina 10), layout of the curve proves their high concentration in direct vicinity of the ports (which is understandable due to the tourist functions of the coastal zone, and the multi-functional nature of the big centres, Tricity in particular). It happens so within the isochrones of 60 minutes. Further, the layout of the curve is more

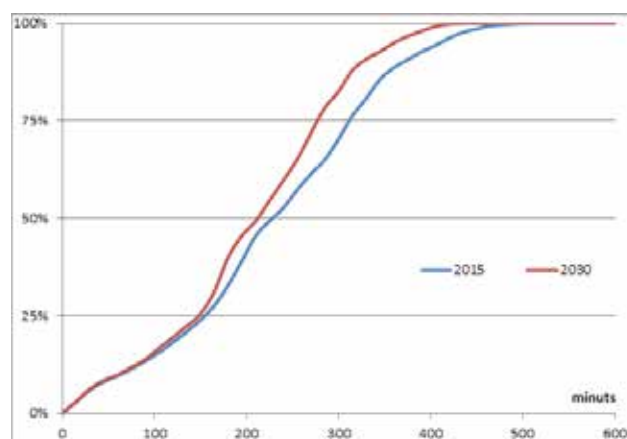
or less linear. In the vicinity of ports, effects of investments from the years 2015-2030 are basically invisible. They can be noticed only outside the isochrone of 180 minutes, which only shows that they are not *de facto* connected with the development of ports and seaport centres. Hence, it has to be assumed that hotel infrastructure of the points under analysis is relatively satisfactory (concentration of hotel beds is much higher than the ones of population and economic operators), but at the same time there cannot be expected any changes in this matter triggered by a development of supra-local transport infrastructure. Hence, the possible actions in favour of further improvement of the situation must be concentrated around the development of tourist accommodation base.

To recapitulate, the defined for the purposes of the survey network of seaports is as a whole comparatively distant from demographic potentials, which may constitute a factor limiting its development. This distance would be even greater if Gdańsk and Gdynia were excluded from the combination subjected to the analysis. A little better is the situation of the ports' hinterland with respect to economic operators' concentration, and especially the hotel beds. The planned investments will significantly improve the accessibility of the network of ports, but it will happen primarily within the zone at a distance from the objects themselves. Thus, it can be assumed that during the demographic crisis they will not influence access to labour resources in a significant way. The investments may, however, have a beneficial impact on the network economic connections (cooperating businesses), and on development of tourism (easier access to areas generating tourist traffic, and a better inner integration of the tourist sites on the Western coast). A better time accessibility to ports of the central coast may constitute a complementary location factor in locating new port infrastructure.

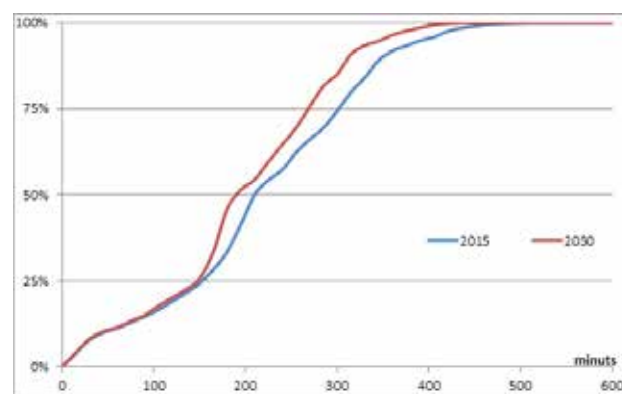
## Conclusions

Interpretation of the discussed above material can be performed in the context of: a) plans of development of the marine economy understood in the broad sense (including the seaports), b) development of tourism; c) providing infrastructure necessary for other forms of exploiting maritime space (e.g. energy sector, defense). While beginning the interpretation, one has to bear in mind the low level of accessibility that has occurred on the central coast so far (a crucial impact on the values and spatial arrangement of the indices).

It should be claimed that great changes of the transportation accessibility may be expected if all the investments planned in the National Spatial Development Concept 2030 are built. At the same time, only part of them will be implemented within the framework of the forthcoming EU's financial perspective. This means that during the next decade in the least, the road infrastructure of the coastal area is going to get its structure reinforced only with the S6 road, the Northern section of the S3 road, and the Tricity ring road (or roads). At the macro-spatial level, also investments situated more remotely from the coast, and above all, within the courses of two express roads – S5 and S7, are to be of certain



Ryc. 8. Accumulated accessibility of the population relative to the network of sea ports in the 2015 and 2030.



Ryc. 9. Accumulated accessibility of economic operators relative to the network of sea ports in 2015 and 2030

influence. Additionally, although the improvement of accessibility is significant, when we consider it in terms of distribution of population and economic operators, as well as the hotel beds, we see that it is going to occur at a distance from the ports of the central coast (Ustka). They will become more accessible to the distant, important centres, but their direct hinterland is not going to change a lot. Not without importance is the fact that changes of accessibility in the region of Tricity are clearly less significant, and that in this case, the primary factor decisive in the issue of the ports accessibility are the domestic solutions of the metropolis.

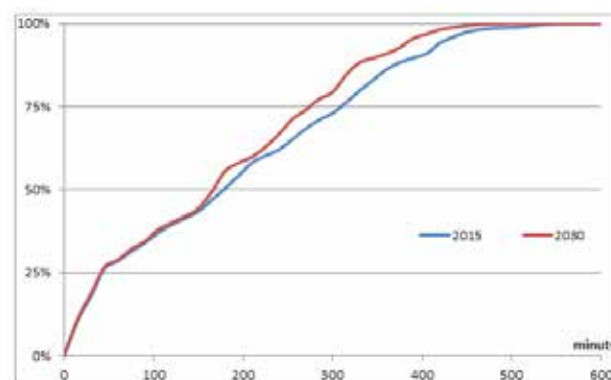
The general assessment issued from the point of view of marine economy reveals that the Polish ports do not have sufficient road connections with the major national centres which constitute their vital economic hinterland (and points where trade with the Scandinavian market is concentrated). Insufficient are also the connections with the Eastern markets. In this context, the situation in Tricity seems most favourable, and its further improvement depends on completion of the S5 and S7 express roads, and on the implementation of investments within the agglomeration. This improvement may be expected to take place within the financial perspective now starting on. Extension of the Szczecin Lagoon ports' hinterland is going to be more problematic though it will also take place after the S3 road is completed. Small ports on the central coast are accessible by the

road system only to a very limited degree and are not likely to improve their situation in the years to come. Implementation of the S6 express road will alter this state only partially (because of it running latitudinally). An improvement would only take place after completion of the S10 and S11 roads listed in the National Spatial Development Concept 2030. Assessing development of marine economy from the point of view of labour market (at the times of demographic crisis and growing role of commuting) it needs to be pointed out that an integrated, spatially big market can currently be found only in the Tricity region. No integration of this kind can be found in the Szczecin-Świnoujście complex, not to mention the central part of the coast. The planned investments are to increase the range of the Tricity metropolis's employment market (e.g. by Elbląg), and will allow an integration of the market within the area of the Szczecin Lagoon. Their influence on small ports' markets is going to be limited.

From the point of view of tourist functions, the level of the coastal zone's accessibility is also not satisfactory both with respect to the long-stay tourism (from the Polish regions further inland, and from foreign countries), as well as the short-stay one (from the nearby metropolitan areas and towns). The central coast is situated beyond the latter type's reach, and when it comes to the time of travel from the Southern Poland, it has lost its competitive advantage over resorts by the Adriatic Sea. In contrast to the development of ports and marine economy, of great importance for tourism is also the implementation of the S6 express road. It will make "weekend" access from the agglomerations of Tricity, Szczecin, and even Toruń and Bydgoszcz much easier, as well as it will improve the internal integration of the Western part of the region (due to its running along the coastline). The effect will, however, remain almost unrecognizable at the Eastern coast (the Northern part of the Pomorskie Voivodeship).

We can also have a look at the already existing and planned road infrastructure through the prism of other economic functions developed at the sea, especially the energetic functions (wind farms). Construction of such objects requires a modern infrastructure (highways' cross-sections, the maximum authorized weights of the cargos) to gain a connection with the seaports, particularly with the small objects on the central coast. In this context, the tangency points of the networks of express roads and ports are of importance. At present, such tangency points can only be found in Gdańsk, Gdynia, and Elbląg. In practice, due to bottlenecks occurring in those centres, the connection actually works solely in Gdańsk. The investments planned within the current curriculum perspective will result in creating tangency points in Kołobrzeg and Świnoujście. At the same time, route of the S6 road provides relatively good connections with other ports on the Western and central coast. With regard to the issue, the worst situation is undoubtedly the one of the Eastern section (between Łeba and Władysławowo). In the context, providing a road service to the possible onshore energy investment (Żarnowiec) should not be neglected.

The conclusions related with the effects of changes in accessibility levels in the chosen ports are presented below in the form of a table (Table II/Tabela II).



Ryc. 10. Accumulated accessibility of hotel beds relative to the network of sea ports in 2015 and 2030

## Recommendations regarding spatial development policy

The performed analysis allows defining certain recommendations regarding spatial development policy and investment actions. They need to be formulated separately with respect to the current financial perspective, and for the period after 2020/2023. The current recommendations may encompass prioritization of the investments that are being planned now, and supplementing them with the secondary networks of investments, which would allow making better use of the already existing infrastructure, and in process of the implementation, or possibly taking preparatory actions toward further operations. Included in this category should be the following indications:

- ♦ to force the pace of preparations towards implementation of the S6 express road's Eastern section, as it is the most important one from the point of view of influencing the potential and time accessibility levels of the central coast;
- ♦ to initiate as fast as possible the implementation of investment of the S3 express road's Goleniów-Świnoujście section;
- ♦ to build simultaneously elements of metropolitan and local infrastructure, which would allow making better use of the big road investments, including first of all the Tricity Agglomeration Northern Ring Road (pl. OPAT) together with a link to the port in Gdynia, as well as the tunnel under the Świna River;
- ♦ to build roads transferring the traffic from express roads (primarily from the S6) to seaports and tourist resorts (to Władysławowo, Łeba, Ustka and Darłowo), including attempts at finding alternative funding sources for those road sections (serving other functions in marine economy and energy sector);
- ♦ to continue preparatory works toward implementation of the S10 and S11 roads;
- ♦ to undertake studies preceding implementation of a ferry terminal, and/or expansion of the commercial port on the central coast with the affinity towards a location in Kołobrzeg. In the long term, a container terminal on the central coast could be also required (intensification of the economic cooperation with Scandinavia).

Tab. 2. Conclusions for the chosen cities/seaports / Wnioski dla wybranych miast/portów morskich

PORT / CITY	LEVEL OF ACCESSIBILITY BY ROADS	PROSPECTED CHANGES IN THE YEAR 2020 PERSPECTIVE	POTENTIAL CHANGES DUE TO COMPLETION OF THE NSDC (KPZK) 2030 INVESTMENTS
Gdynia	Good accessibility at the national scale; poor one from the west and north, and in terms of metropolis's internal accessibility; Tricity agglomeration's integrated labour market	Relatively small effects of the planned investments. Improvement of accessibility from the inland areas (and from Eastern Europe), crucial for the port's economic hinterland; no effects on the agglomeration's internal issues; better integration of Tricity's labour market (strip of land from Lębork to Elbląg)	No further significant effects of accessibility's improvement
Świnoujście	Low level of accessibility in terms of road transport, partially conditioned by the peripheral location; lack of road system's cohesion with other ports of the Szczecin Lagoon region; problems with internal accessibility (fixed crossing); a "dissociated" labour market	A significant improvement of accessibility by roads in case the northern section of the S3 express road is built; possible integration of labour market with Szczecin; a chance for an effective usage of all the earlier investments connected with the S3 road's route; integration of the west coast's tourist region	Further improvement of accessibility at the national scale due to implementation of the S10 express road
Ustka	Low level of accessibility in terms of road transport; limited hinterland for the short-stay tourism; limited and "dissociated" labour market	Noticeable effects of accessibility's improvement due to the S6 express road (mainly with respect to Tricity); improvement of the tourist region's integration; a small growth of the labour market	A significant improvement of accessibility at national scale due to the S11 express road, though the possibilities of labour market's expansion remain limited
Elbląg	Relatively good level of accessibility in terms of road transport; a limited hinterland for the short-stay tourism	A clear improvement of access in direction of Tricity, and a smaller one in that of Warsaw; integration of labour market with Tricity; no clear growth of tourist hinterland	No further significant effects of accessibility's improvement
Kołobrzeg	Low level of accessibility in terms of road transport; a limited hinterland for the short-stay tourism	Noticeable effects of accessibility's improvement due to the S6 express road; improvement of the tourist region's integration; a growth of the labour market	Significant further rise of accessibility at national level (a basis for port's development) thanks to the S11 and S10 express roads, though possibilities of labour market's extension remain limited
Darłowo	Low level of accessibility in terms of road transport; a limited hinterland for the short-stay tourism	Noticeable effects of accessibility's improvement due to the S6 express road; improvement of the tourist region's integration; a growth of the labour market	Significant further rise of accessibility at national level thanks to the S11 express road though possibilities of labour market's extension remain limited

Taking into consideration the records in the National Spatial Development Concept (KPZK) 2030, it seems purposeful that completed in the period after the current perspective is concluded should be first of all:

- ◆ implementation of the sections of S10 express road from Bydgoszcz to Piła, and of road S11 from Poznań through Piła to Koszalin (an arrangement ensuring a good accessibility to the central coast's from the continental areas of the country);
- ◆ activation of a ferry terminal (or possibly two of them) on the central coast (only in case the above-mentioned road structure is implemented simultaneously), with indicating Kołobrzeg as the first terminal's location;
- ◆ construction of the Szczecin agglomeration Northern ring road;
- ◆ completion of the road interconnectors (the dead-ended express roads suddenly turning into class GP roads, and next into ordinary roads distributing the traffic over the

coast) providing service to the coastal cities through the already existent system of motorways and express roads, including the following routes: a) Reda-Puck-Żarnowiec; b) Lębork-Łeba, c) Słupsk-Ustka, d) Sławno-Darłowo, e) Nowy Dwór Gdański – Sztutowo.

The issue of a possible port situated on the central coast should be considered in variants. With assumption that the full network of express roads recorded in the National Spatial Development Concept (KPZK) is to be completed, and that the need to create a port/terminal of national importance is to be recognized, the first indication for its location seems to be Kołobrzeg. Should the transport needs turn out to be smaller, the S10 and S11 roads would not be implemented, and indication for the alternative port's/terminal's location would not be so explicit. In such a situation, certain advantages plead in favour of Darłowo's location (with the additional necessity of ensuring a connection between the port and the S6 express road).

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