Runoff extremes caused by the climate change and their impact on territories under the flood risk

Work package 9

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KALME
VALSTS PĒTĪJUMU PROGRAMMA
KLIMATA MAIŅAS IETEKME UZ LATVIJAS ŪDEŅU VIDI

Work package objective

The aim of this work package is to forecast climate change impact on recurrence and regime of runoff extremes: floods and droughts. Identify the impact of these phenomena on flood-plain ecosystem in the Middle-Daugava region.

Work package tasks

1. Assessment of historical and current frequency of flood recurrence and climate change impact on it;

2. Forecast changes in regime of floods and drought based on the scenarios of hydrological regime;

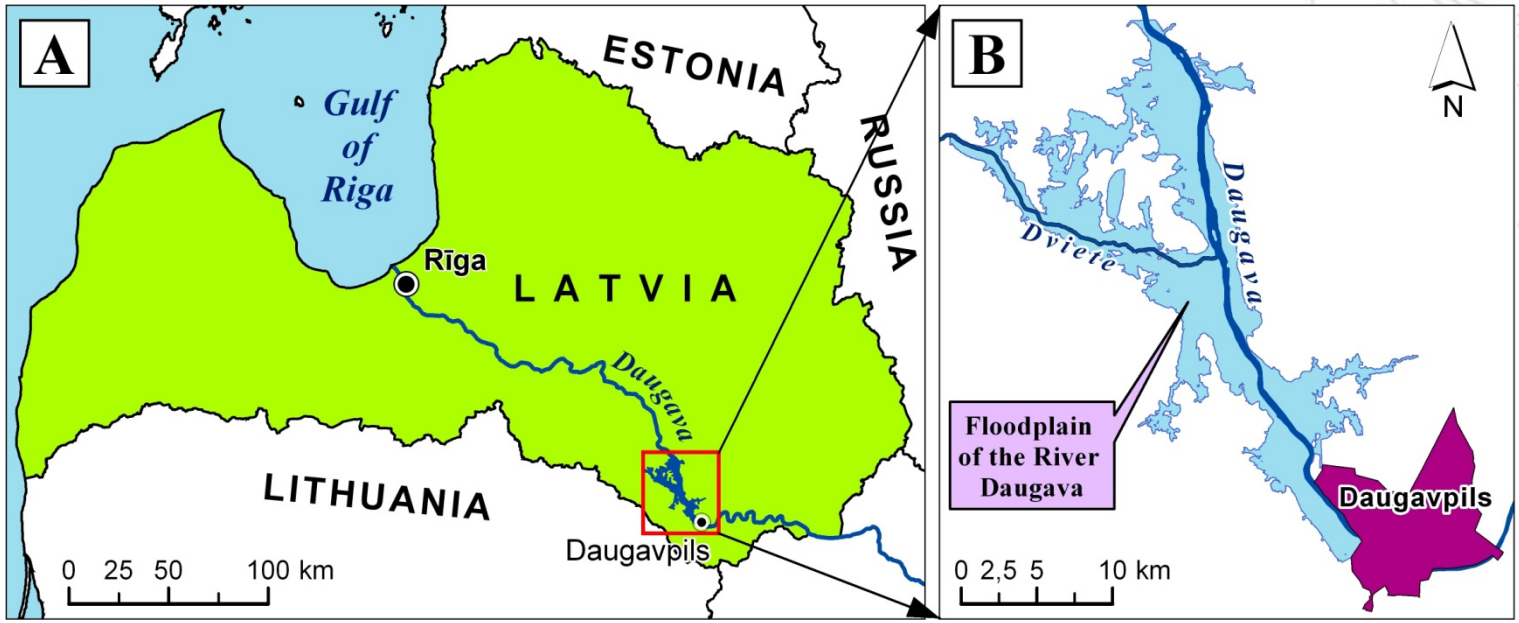
3. Identify the role of natural flood-plains in stabilizing of hydrological regime;

4. Determine flood and drought impact on bio-geochemical fluxes in flood-plain systems and the catchment;

5. Assess the impact of floods and droughts on floodplain-lake ecosystems of river Daugava;

6. Mitigation of flood and drought risk.

Location



The biggest natural floodplain in Latvia is located within the Daugava valley stretch from Daugavpils City down to Jersika, where the river cuts through the Baltic Morainic Ridge and in its further course flows across the Eastern Latvian lowland.

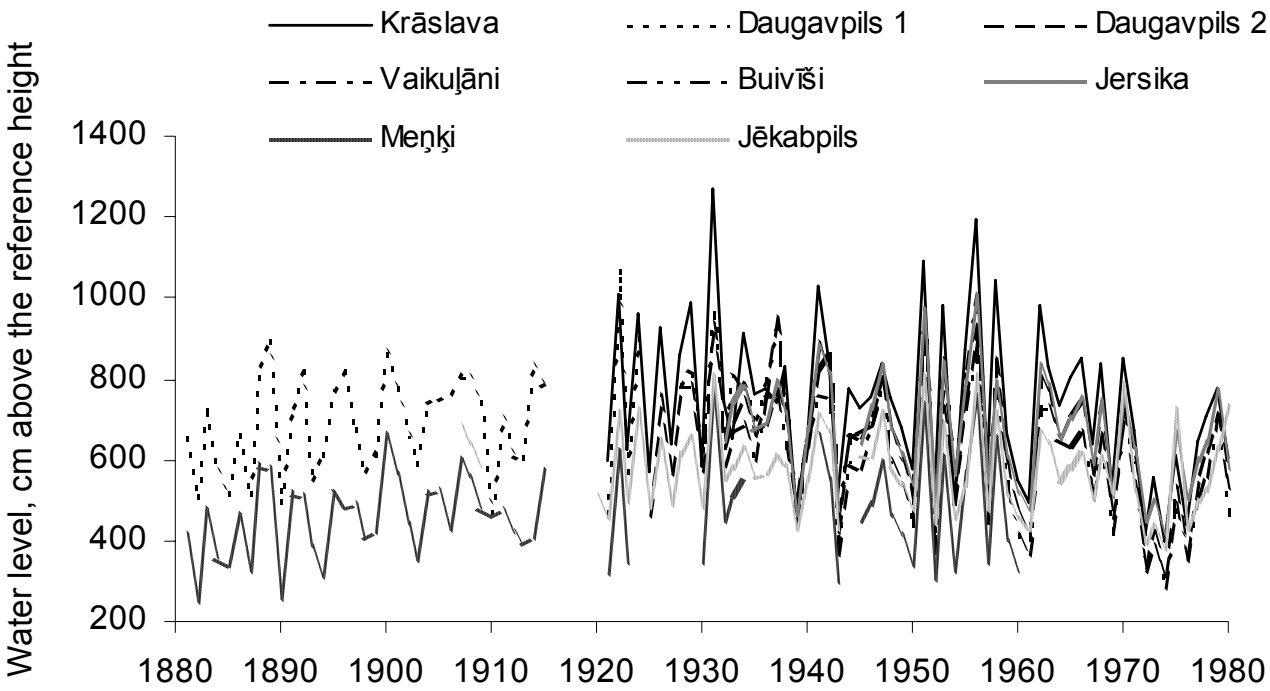
Flood recurrence

Almost rectilinear river flow of the Middle Daugava in territory under study is characterized by very low stream gradient as 0,05 m km^{-1}. Valley in this stretch is shallow, only 4-8 m deep and very wide (up to 4 km). Both these features also entail flooding problems, due to even relatively small rising of water level can bring an inundation of large areas adjacent to stream.

Flood recurrence

About half of the total mean annual amount of the Daugava runoff is formed during the spring floods. The largest discharge is usually observed in April, during the intense snowmelt. The mean largest discharge (1600 $m^3 s^{-1}$) is usually observed at the same time.

Flood recurrence



The existing meteorological and hydrological data series were summarized and statistically analyzed. The post at Daugavpils operates continuously since 1881 except for 1915 and 1917-1921 when observations were interrupted. In order to get an uninterrupted series of the observed diurnal runoff values, only those data obtained between 1922 and 1987 were statistically analyzed.

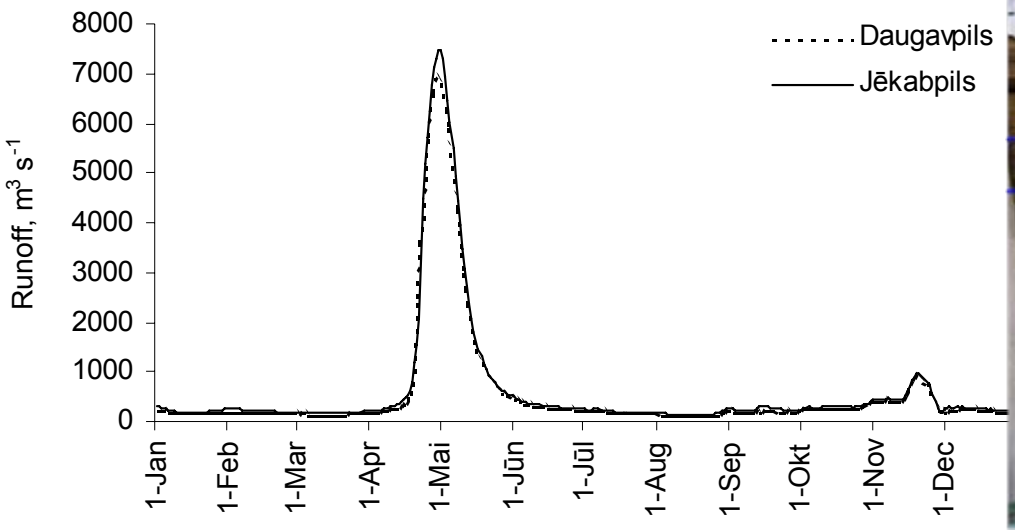
Flood recurrence

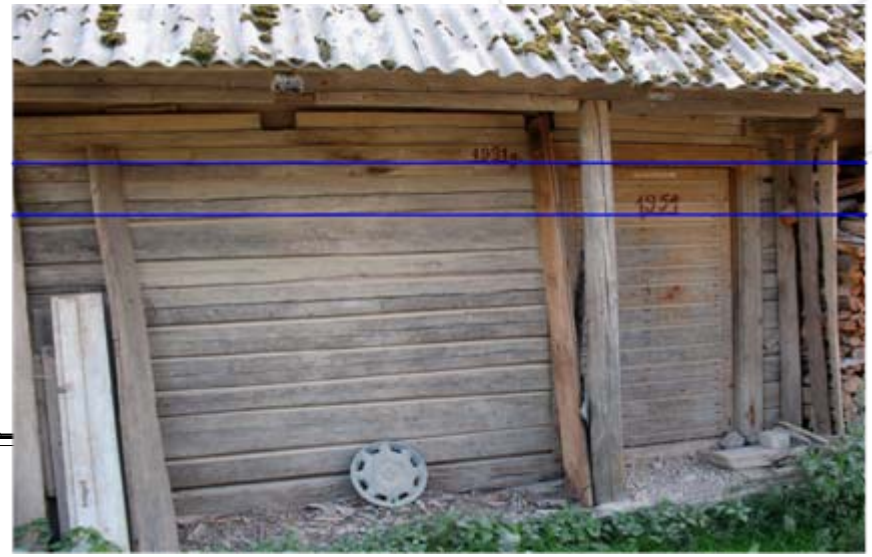
Maximum runoffs of the spring floods with different periods of their reoccurrence according to the Gumbel's distribution (1922-1987)

Probability, %	Reoccurrence period, years	Runoff, m^3/s
1	100	6468
5	20	4962
10	10	4297
20	5	3604
50	2	2557

Until now, the highest runoff values and water levels were observed during the catastrophic spring floods of 1931, 1951 and 1956. During floods of 1931, the maximum runoff reached the record values (**6930** $m^3\ s^{-1}$ at Daugavpils and **7470** $m^3\ s^{-1}$ at Jēkabpils).

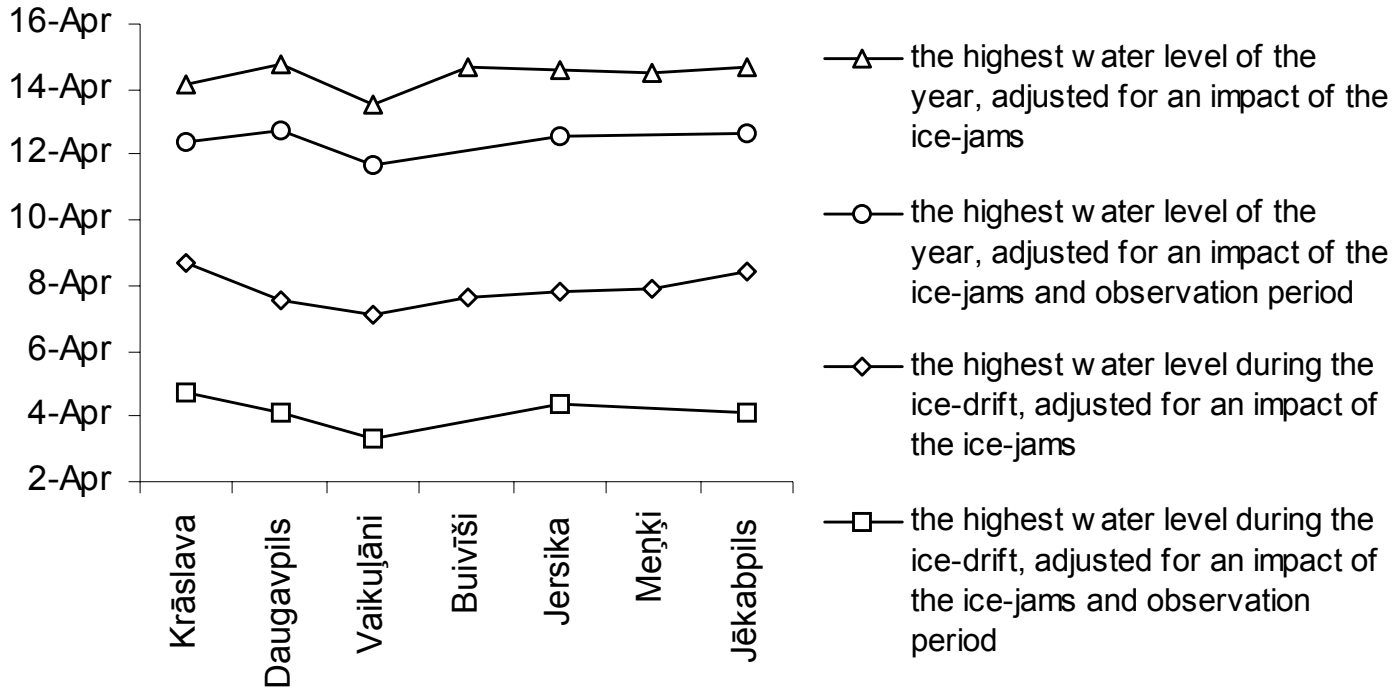
Flood recurrence



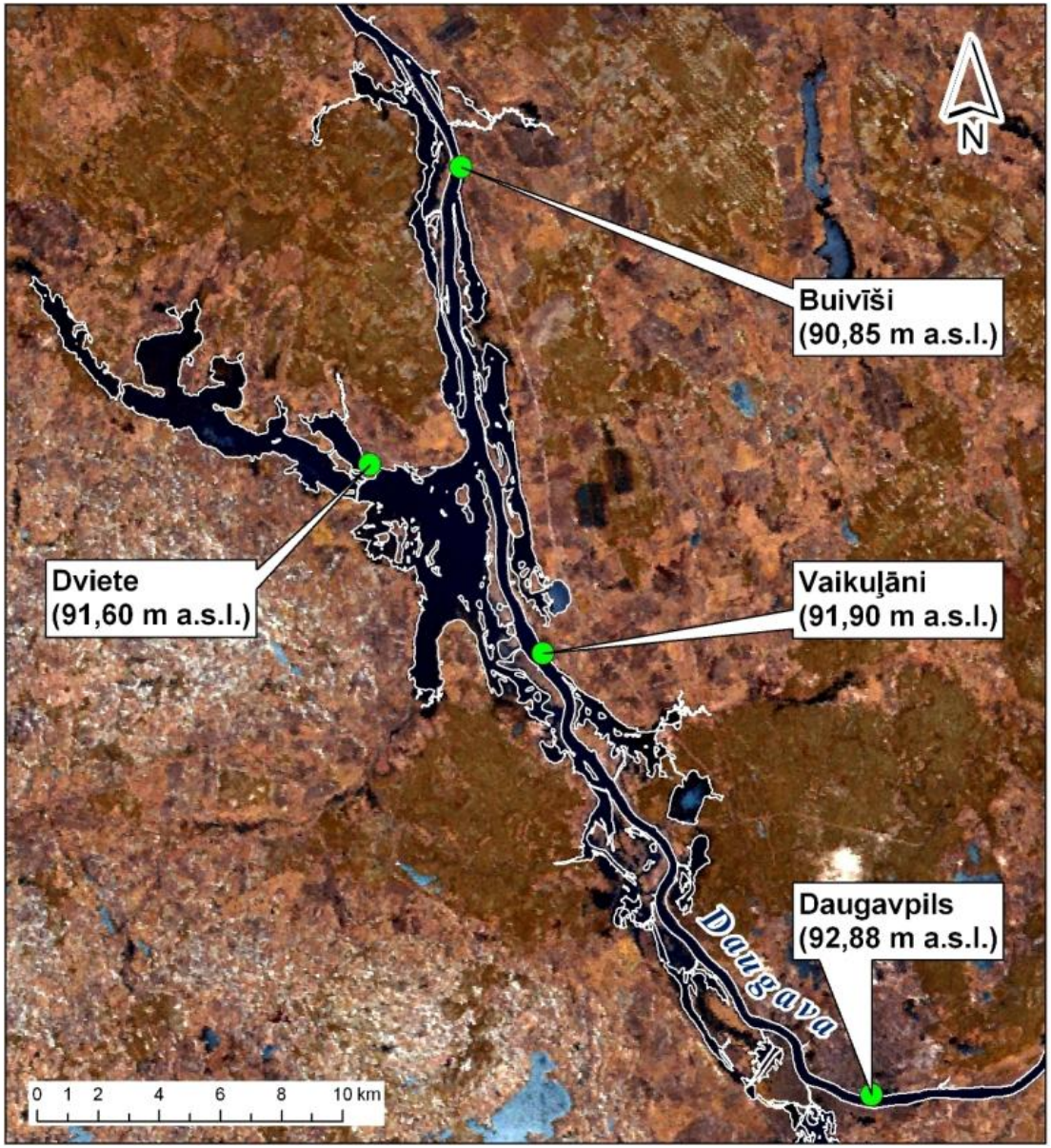


According to historic observations of the Daugava water regime, the water level rises quickly at the beginning of floods and drops down about two times slower when the highest peak has passed. It could be explained only if an impact of the floodplain is considered. It is a large natural buffer which intercepts a considerable amount of the Daugava runoff, reduces the amplitude of water level fluctuation and detains the rise of the water level.

Hydrological role of the natural floodplain



The highest water levels in the Daugava River are usually higher than those observed during the ice-drift period. Accordingly, there is also a significant shift in the dates when these two high water levels are observed. The highest water level of the year is usually observed on 12-14 April whereas the highest water level of the ice-drift period is observed considerably earlier, on 4-8 April, depending on the method of the data adjustment.


N
Buivīši
(90,85 m a.s.l.)
Dviete
(91,60 m a.s.l.)
Vaikuļāni
(91,90 m a.s.l.)
Daugavpils
(92,88 m a.s.l.)
Daugava
0 1 2 4 6 8 10 km

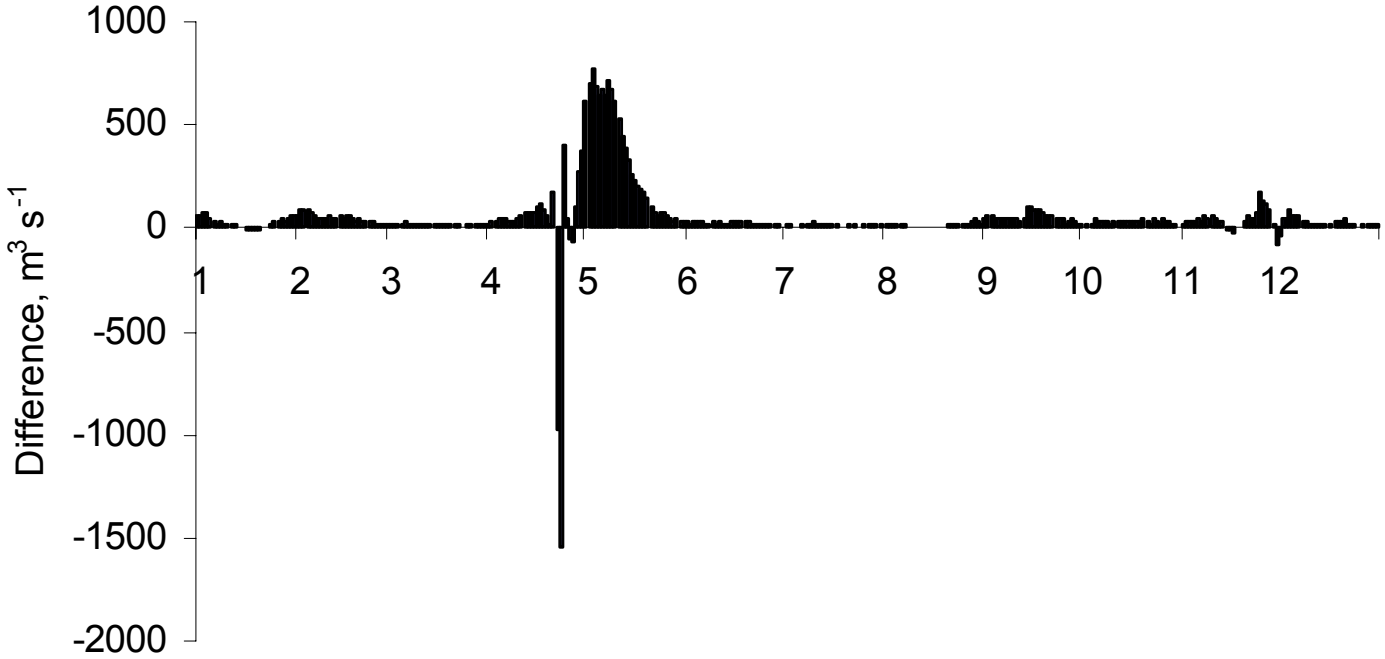
Hydrological role of the natural floodplain

After the statistical analysis of the historical annual data, two hydrological functions of the Middle Daugava floodplain could be revealed.

First, the floodplain considerably reduces the amplitude of water level fluctuation per year, and, second, it significantly detains the timing when the highest water levels of the year, as well as during the ice-drift, are reached.

However, it is also possible to evaluate the amount of the daily and annual runoff that could be intercepted and stored within the floodplain between Daugavpils and Jēkabpils during the floods.

Hydrological role of the natural floodplain



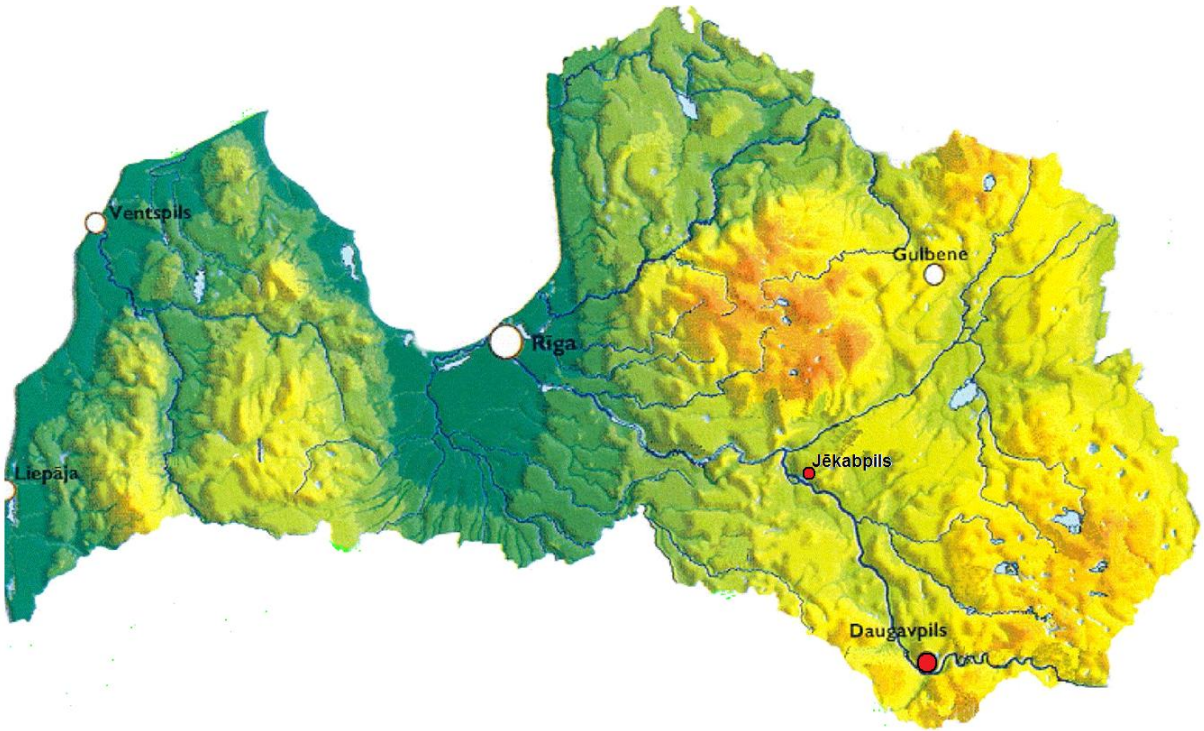
The highest daily runoff values in the Middle Daugava were observed during the record spring floods of 1931. During these floods, there were several days, when the daily runoff values at Daugavpils were considerably higher than those at Jēkabpils. Therefore, the calculated differences between daily runoff values were negative. On 23 April, they reached even 1550 $m^3 s^{-1}$ or $1,34 * 10^8$ m^3 per day, which accounts for 43,1 % of the total runoff of the Daugava River at Daugavpils on this day.

Hydrological role of the natural floodplain

Units	Total runoff (Q)			Added by local runoff (the sum of positive differences)	Intercepted by the floodplain (the sum of negative differences)
	Daugava at Daugavpils	Daugava at Jēkabpils	Total difference		
km^3 per year	17.78	19.44	1.66	1.90	0.24
%	100.00	109.32	9.32	10.69	1.38

Similar cases were observed in other years too, when the daily runoff values at Daugavpils and Jēkabpils are compared. This phenomenon was usually stated at the beginning of floods, during a rapid rise of water level, and continued for several days until the runoff at Jēkabpils overcame that at Daugavpils. In the result, a significant interception of the Daugava annual runoff between the Daugavpils and Jēkabpils hydrological posts was discovered. In the case mentioned above, the sum of the negative differences in daily runoff values reached 0,24 km^3 per year, or 1,38 % of the total annual runoff of the Daugava at Daugavpils in 1931 (Table above).

Hydrological role of the natural floodplain



However, the calculated sum of the negative differences in the daily runoff values could no be strongly attributed to the floodplain interception alone because there is a large distance between the Daugavpils and Jēkabpils posts (about 100 km). In order to get a more realistic idea about the floodplain role in the interception and storage of the Daugava daily runoff, it is also necessary to adjust the data to this factor.

Hydrological role of the natural floodplain

According to the results of the prolonged drift experiment which was performed along the Middle Daugava downstream from Daugavpils City on March 28, 2007, the mean drifting velocity of the moving water mass was about 4,4 km per hour at the height of the spring floods. Therefore, the mass of water which passes the Daugavpils hydrological post during the floods drifts for about 24 hours before it reaches the vicinity of the Jēkabpils post.

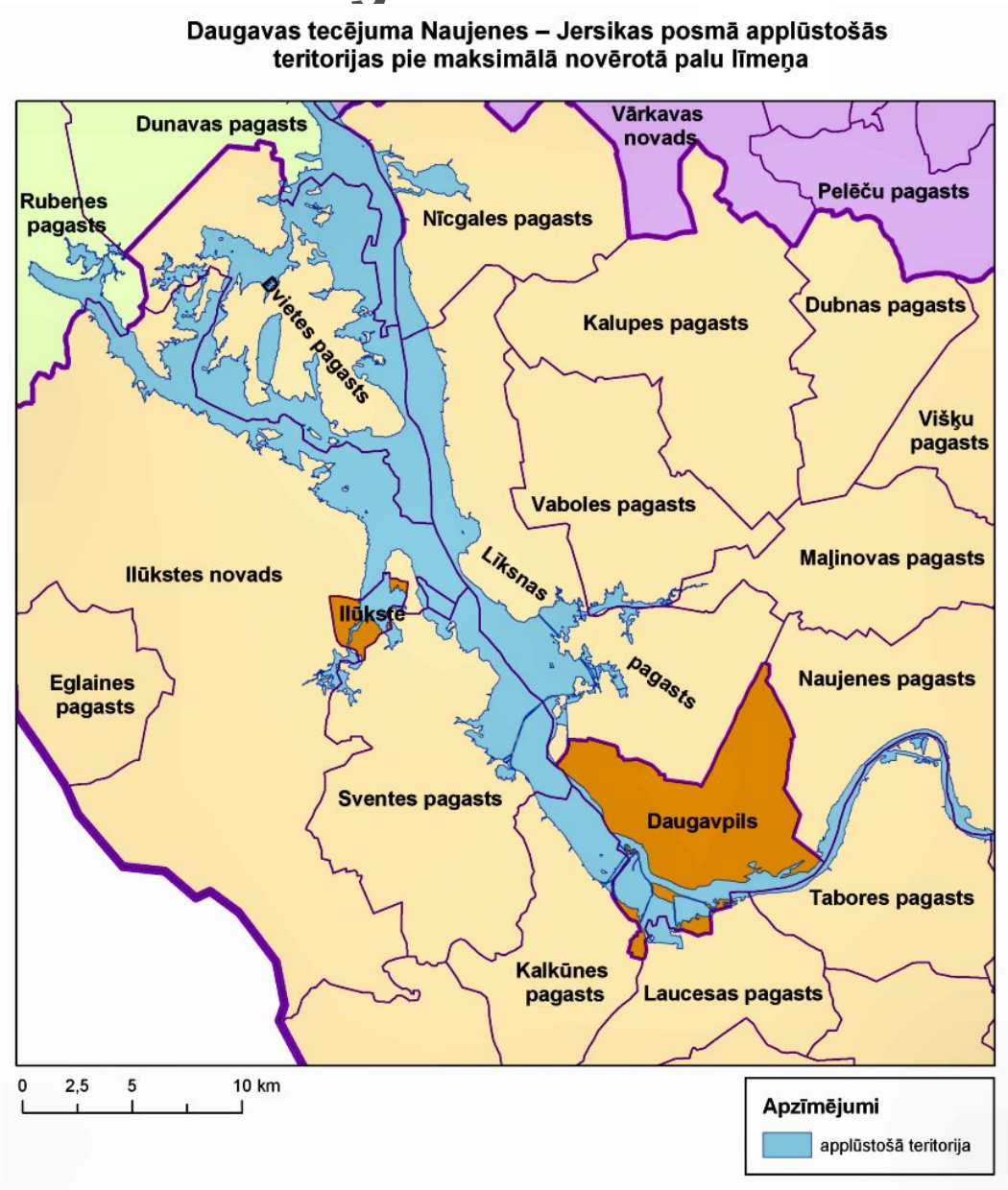
Hydrological role of the natural floodplain

After such corrections, the daily runoff values at both hydrological posts become very similar to each other, and much smaller negative differences are obtained. In the case of the record floods in 1931, the highest negative difference was stated for 22 April. It was about 470 $m^3 s^{-1}$ or $4,06*10^7$ m^3 per day, which accounts only for 18,7 % of the total runoff of the Daugava River at Daugavpils on that day.

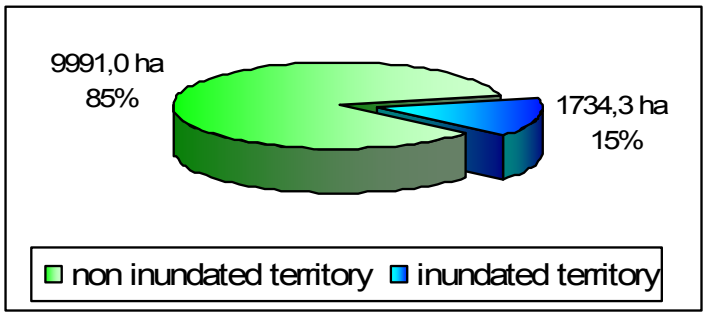
Hydrological role of the natural floodplain

Estimation of floodplain capacity to receive and to store water during inundation demonstrates that volume of water accumulated during mean flood level exceeds value 0,31 km^3. At the same time, amount of suspended sediment matter accumulated within floodplain exceeds value of 26’000 t or 0,125 kg m^{-2} at mean concentration of suspended sediments 250 mg l^{-1}.

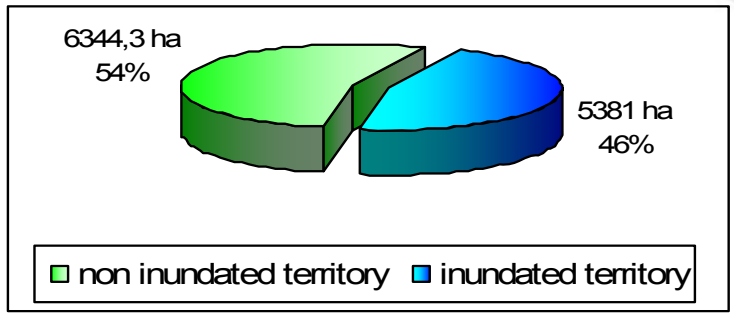
Mitigation of flood risk



Hydrological role of the natural floodplain



Proportion of inundated territories in Dviete municipality *at mean annual flood level.*



Proportion of inundated territories in Dviete municipality *at maximal flood level.*

Geospatial analysis of the obtained data show that Dviete and Pilskalne rural municipalities are the most endangered by the risk of flooding within the whole Daugava valley from Daugavpils City to Jersika. Accordingly, 15% and 13% of the total territories of these municipalities could be inundated at mean annual flood level. At the maximal flood level 46% and 21% of total territory of municipalities could be inundated.

Conclusions

Major hydrological functions of the Middle Daugava floodplain are as follows: (1) reduction of annual amplitude of water level fluctuation by 3-4 meters; (2) detention of the timing of the highest flood water levels in the year by 1-2 days downstream from the Dvietes floodplain; (3) interception of approximately 20 % of the Daugava daily runoff amounts at the beginning of the floods.

In addition, the floodplain accumulates a large amount of suspended and dissolved matter, which, in turn, stimulates productivity of floodplain meadows, wetlands and lakes. Floods are regarded as an essential factor of maintaining the high biological diversity in the river floodplain ecosystems.

Conclusions

While completing the second stage of the state research programme, a study of the ecosystem complexes in the flood-plain of the Daugava mid-stream was undertaken. Historical and current frequency of the repetition of extreme discharge in Daugava was assessed, and recommendations in regards of the flood risks were worked out for the involved municipalities in the Daugavpils region.


Thank you for the attention!