

Review of the Ph.D. thesis of M.Sc. Babak Ghazi ‘The occurrence and causes of floods in Polish lands from the 11th to 18th centuries’

(„*Występowanie i przyczyny powodzi na ziemiach polskich od 11 do 18 wieku*”)

The subject of Babak Ghazi's doctoral dissertation is highly significant and very timely due to the occurrence of floods and flash floods, as well as the widespread, often media-driven, discussion regarding their causes. Recent months in Poland and other parts of Europe have seen many extreme weather events, including heavy rainfall of varying nature, leading to floods and flash floods. Therefore, knowledge about floods from past centuries seems to be very important for a proper assessment of current hydrometeorological events. Moreover, I believe that such an assessment cannot be made without referencing history from previous centuries, including the pre-industrial period when there was no anthropogenic impact on the environment, including weather and hydrological events. Additionally, as indicated by the dissertation title, besides assessing the frequency of floods, attention was also given to their causes. This further allows for a reflection on contemporary meteorological and hydrological events.

The doctoral dissertation of Mr. B. Ghazi is based on four multi-authored scientific publications. Three of these are already published articles in reputable international journals. The number of authors ranges from 5 to 6, with the doctoral candidate being the first author and corresponding author in each case. The dissertation also includes a manuscript that is valuable in terms of content and has been submitted to the journal "Scientific Reports." It is unfortunate that this manuscript cannot yet be considered a fully-fledged article, but current regulations concerning doctoral dissertations allow for such works to be evaluated (the so-called hybrid form of a dissertation).

The reviewed dissertation includes the following scientific papers (P1-P4):

Ghazi B., Przybylak R., Oliński P., Bogdańska K., Pospieszńska A., 2023, The frequency, intensity, and origin of floods in Poland in the 11th–15th centuries based on documentary evidence, Journal of Hydrology, Vol. 623. <https://doi.org/10.1016/j.jhydrol.2023.129778> P1

Ghazi B., Przybylak R., Oliński P., Chorążyczewski W., Pospieszńska A., 2023, An assessment of flood occurrences in Poland in the 16th century, Journal of Hydrology: Regional Studies, Vol. 50. <https://doi.org/10.1016/j.ejrh.2023.101597> P2

Ghazi B., Przybylak R., Oliński P., Targowski M., Filipak J., Pospieszńska A., 2024, A comprehensive study of floods in Poland in the 17th–18th centuries, Journal of Hydrology: Regional Studies, Vol. 53. <https://doi.org/10.1016/j.ejrh.2024.101796> P3

Ghazi B., Przybylak R., Oliński P., Pospieszńska A., Flood occurrences and characteristics in Poland in the last millennium, Manuscript submitted to Scientific Reports P4

The list of the above-mentioned works is provided at the beginning of the received dissertation abstract (Guide), which has a total of 112 pages. Additionally, the doctoral candidate included a list of other conference publications related to the dissertation's topic, as well as other publications in which he was a co-author. From a formal point of view, I note that two conference publications (presentations) have not yet been delivered (positions 1 and 2). The first substantive part of the abstract contains the so-called general statement, which presents the structure of the entire dissertation by describing the content found in the subsequent four papers (P1-P4). This section, only two pages long, is crucial as it introduces the reader to the entire dissertation.

The first article of the dissertation (P1) is dedicated to assessing the occurrence of floods in Poland during the medieval period (11th-15th centuries). Although this period spans 500 years, it was particularly difficult to assess reliably due to the scarcity of data on the phenomenon in question. Very similar scopes of analysis are found in the subsequent articles, P2 and P3, which cover the 16th century and the 17th-18th centuries, respectively. It is worth noting that in article P3, the results of analyses of flood frequency in various regions of Poland are presented and compared with several European rivers.

The work presented as a manuscript (P4) contains interesting analysis results that supplement the assessment of flood frequency in Poland over the last 200 years (i.e., the 19th and 20th centuries). This allowed for a comprehensive view of floods throughout the entire second millennium. This work also draws attention to the occurrence of floods in many cities.

It should be added that the work was carried out as part of an NCN research project (2020/37/B/ST10/00710), led by Prof. R. Przybylak. Incidentally, it should also be noted that as a result of this project, four databases were created, comprising a list of historical floods in the Polish territories, which served as the basis for the analyses conducted by the doctoral candidate. All the databases are available online (the files are saved in Excel format) and are hosted on the server of Nicolaus Copernicus University in Toruń. Given their scientific content, they constitute a reliable source for the conducted analyses. The abstract does not specify the extent to which Mr. B. Ghazi was involved in the creation of these databases or whether he only used the data in his dissertation or also participated in their preparation. However, familiarization with the information about these databases clearly indicates that the doctoral candidate was a significant co-creator, leading to the conclusion that his role in the creation of the doctoral dissertation is fully satisfactory and not limited to merely processing collected data.

In the subsequent parts of the abstract, there are summaries of the work in both English and Polish, as well as an introduction. The introduction plays an important role in the dissertation, as it not only presents a brief overview of the state of research in the field of historical flood identification in Poland and Central Europe, but also formulates the research objective. This objective is to assess flood phenomena and their spatiotemporal changes in Poland during the so-called pre-instrumental period from the 11th to the 18th century, based on currently available research materials, primarily historical documents. Although this objective could have been articulated more clearly, it is nonetheless scientifically valuable and raises no doubts. It is further clarified by the addition of five specific objectives.

In summary, the work has a broad scientific impact, covering many specific issues in the fields of hydrology and historical climatology. Given this fact and the extensive knowledge required from other disciplines, especially history, it can be concluded that the work is thoroughly interdisciplinary.

In the next part of the abstract, the author presents the source materials and the methods applied. As previously mentioned, the analyses were based on four available databases on floods in Poland covering the following periods: the 11th-15th centuries, the 16th century, the 17th-18th centuries, and additionally, the 11th-18th centuries. These databases included information about individual flood events (including, among other things, the magnitude and cause of each flood) along with their so-called metadata. The latter is a valuable resource concerning the quality of the data used, which, as is known, can come from very diverse sources that are not always fully verified or reliable. In fact, in this type of analysis, whether in hydrology or climatology, proxy data is often used, necessitating a very broad and comprehensive perspective as well as knowledge across many specific issues.

As stated, for the entire period from the 11th to the 18th century, 563 data sources containing 1,345 weather-related notes were analyzed. These numbers provide a sufficient base for conducting reliable research on the frequency of floods in Poland during the 11th-18th centuries. Unfortunately, as one might expect, the availability of data for the entire 800-year period is not uniform. In the first five centuries, the availability of weather-hydrological notes is significantly lower than in the later centuries, from the 16th to the 18th century. This means that the hydrological-meteorological information for the first 500 years of the analyzed period is considerably poorer—both in quantity and quality—therefore not allowing for reliable comparative analyses with the later centuries. This fact is crucial for conducting research and drawing conclusions over the entire period from 1001 to 1800. It naturally leads to slightly lower reliability of the results and greater uncertainty.

I want to strongly emphasize that I mention this not as a criticism of the entire work but as an important element that must be considered for conducting critical analyses. According to the abstract and the four included papers, the author is aware of this fact, which, in my opinion, should be viewed very positively. Of course, the lack of an adequate amount of data or its appropriate quality could be a reason not to pursue certain scientific topics, but conducting research under such limitations presents a true scientific challenge and contributes to the expansion of knowledge and the development of science as a whole, including Earth and environmental sciences.

The applied research methodology raises no concerns. The author implemented a methodology previously developed by other authors (Barriendos & Coeur, as well as Brazdil) and the renowned Polish hydrologist Lambor. This methodology is briefly presented by the doctoral candidate in five points and is also clearly depicted in the form of a diagram in publications P1 and P2. It is perhaps unfortunate that this diagram was not included in the abstract instead of the description.

I positively evaluate the use of the well-known Mann-Kendall statistical test to assess potential changes in flood frequency. It is hoped that this test allowed for the detection of data inconsistencies, which may have arisen from access to objective, artifact-free data. I must emphasize that the issues of data quantity, quality, and homogeneity in this type of research are key challenges. However, various formulations by the author of the dissertation, both in the abstract and in the individual works included in it, suggest that he is aware of this. There is a cautious approach to drawing conclusions in some places, although this issue of data uncertainty could have been emphasized even more in the work.

The next and most extensive chapter of the abstract is the discussion of the obtained results (Chapter: Results). These results are detailed in the four attached works (three articles and one manuscript). In my opinion, this section contains all the most important findings that emerge from the conducted research. The author sequentially presents quantitative listings of identified floods throughout the entire study period, as well as in shorter intervals across Poland and in its various regions. He also highlights their number (frequency) in different seasons and, most interestingly for climatologists, the meteorological causes of floods. I can only regret that this information cannot be more detailed due to the lack of reliable data. The subsequent topics discussed include the intensity of floods and their frequency in various cities. These latter aspects are thoroughly presented in publication (manuscript) P4.

I fully and positively evaluate the discussion of the obtained results, particularly where attention is drawn to the uncertainty and bias of documentary evidence, which pose significant challenges in identifying various hydrometeorological extreme events, including historical floods. The final part of the abstract consists of the conclusions, which list the most important features of the temporal and geographical distribution of identified floods in Poland during the period 1001-1800. The key quantitative conclusions are formulated in eight points. All of these are extremely significant because, for the first time on a national scale in Poland, such an assessment of flood occurrences has been made.

The identified number of 1,680 floods over 800 years may be somewhat surprising to some researchers, averaging about two floods per year. This fact may also raise doubts, especially when confronted with contemporary perceptions of torrential rains or heavy widespread rainfall, and consequently, flood events of varying nature and extent. It is also worth noting, though it is relatively underemphasized in the work, that this number is likely underestimated due to limited data on floods during the first 500 years. I personally consider it very important to note that, historically, floods most frequently affected the Oder River basin (55%), particularly in the region of Silesia. Conversely, it seems somewhat surprising that the frequency of floods in the Małopolska region is relatively low (17%), despite this area being frequently affected by such events in modern times.

As a climatologist, I take particular interest in the information that 44% of floods were caused by rainfall, especially since these most often occurred in summer. It is unfortunate that the causes of floods could only be determined for 60% of the cases. Perhaps including a greater number of instances could have altered the frequency distribution of their causes. Of course, I am aware that in such assessments, one must consider the spatial extent of these flood events. I am nearly convinced that, from a methodological standpoint, it was impossible to account for the majority of flash floods with a very small local extent, which, even today, despite advanced atmospheric and hydrospheric monitoring, can sometimes be overlooked.

An interesting conclusion concerns the trends in flood occurrences throughout the entire studied period as well as in specific subperiods. However, I suggest caution in formulating these conclusions due to their significant variability over the past centuries and decades. The results obtained in this regard are merely a statistical approximation of the phenomena under consideration. The last of the formulated conclusions, which pertains to the higher frequency of flood events in Germany and Poland compared to the Czech Republic and Austria during the 11th-18th centuries, is intriguing, though it may raise some doubts. Personally, I am curious about the doctoral candidate's opinion on the reasons for such a disparity. At the end of the

conclusions, the author presents his recommendations for future research. I fully agree with them, as they pertain to extreme events, improving the reliability of input data, and future climate-hydrological scenarios.

In evaluating the content of the entire dissertation, I do not specifically address the articles that constitute it. As is known, these articles have already undergone thorough and critical review during the entire publication process. Of course, in any scientific work, one can find points or questions for discussion, which are an inherent part of the research process. For example, I point to the identification of the number of floods in Fig. 3 (submitted article manuscript, page 7; doctoral manuscript, page 91) for the Oder and Vistula basins. The values marked on the OX axis are unclear, it is not evident what basic time intervals were considered, and additionally, Fig. S2, to which the authors refer, cannot be found.

The manuscript of the entire doctoral dissertation is well presented, although its clarity could be improved. When initially studying it, the reader might have doubts regarding page numbering, references to figures, or tables. Here and there, one might expect greater care and precision in the presentation of the content. For instance, on the title page of the abstract, the dissertation supervisors are listed without distinction of their roles, the author's bibliographic notes are incomplete, individual chapters could have been numbered, and so on. The literature used in the work, both Polish and international, is extensive, although it might have been worth including a few additional significant works (e.g., S. Czaja's 2011 monograph on floods in the Upper Oder basin).

From a formal point of view, it should be stated that all the publications included in the dissertation form a cohesive whole aligned with the title of the work and its objectives. Of course, in several papers, particularly P3 and P4, there are contents that extend beyond the area of Poland, but I view this broader spatial reference positively. The doctoral candidate's contribution to the authorship of the individual papers and his dominant role in their preparation raise no doubts. Each of the included papers contains information about the qualitative contributions of the respective authors. Given the high ethical standards of the dissertation's principal supervisor, I have no doubts regarding the contributions of the individuals involved in the preparation of the dissertation. From an administrative perspective, I would like to note that the Regulation of the Minister of Science and Higher Education of September 26, 2016 (reiterated in the Regulation of January 19, 2018) includes a detailed provision regarding the necessity of co-authors' statements for publications (paragraph 5, point 2).

In summary, I conclude that the presented doctoral dissertation represents a significant contribution to the contemporary discipline of Earth and environmental sciences, particularly

in the fields of hydrology and climatology. The work makes a substantial scientific contribution to historical hydrology and climatology. At the same time, it poses new research challenges both in relation to past environmental events and, in light of these, to contemporary and future projected events.

The few substantive critical remarks or doubts included in this review should prompt the author to thoroughly consider the issues raised during the continuation of their research and/or when preparing future publications. These remarks do not affect the overall very positive evaluation of the entire dissertation. The results obtained and their presentation in the form of the abstract, along with the attached works, allow for a clear conclusion that the dissertation provides an original solution to a scientific problem, demonstrates the doctoral candidate's general theoretical knowledge, and shows that the candidate possesses the ability to conduct independent scientific work. Therefore, in accordance with the provisions contained in the "Law on Higher Education and Science" of July 20, 2018 (Article 187), I state that the dissertation presented to me for review meets the criteria required of doctoral dissertations, and I recommend that the High Council of the Discipline of Earth and Environmental Sciences at Nicolaus Copernicus University in Toruń admit Mr. Babak Ghazi to the subsequent stages of the doctoral process.