Impact Based Forecast analysis uses multi-model ensemble data and National Digital Forecast data in ArcMap 10.8.1

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Abstract. The number of people seeking public weather service information is growing, making it a challenge for all bureaus of meteorology around the world. Although, in the last decade, routine public weather service information has brought excellent weather forecast information for people and services to people with rapid, accurate, widely available, and easy to grasp information, which they may get in a variety of places, such as a website or an application. However, in this decade and in the future, it will not be enough. People want information such as what the impact should be and how people react to that impact, which should be displayed on a static Geographic Information System (GIS) map in a standard format. We will investigate and create an IBF map based on multi-model ensemble data and National Digital Forecast (NDF) data in this work. Then, using the GIS software ArcMap 10.8.1, we rank and score the geographic disaster data to determine the impact area. To create the effect area, we will employ primary and advanced methods of ArcMap 10.8.1. The information on the IBF map will be immediately understood by stakeholders and users.

Keywords: Multi-Model Ensemble, NDF, Disaster Data, GIS, IBF

1. Introduction
Indonesia is a maritime continental with a complex and distinct dynamic atmosphere [1]. Almost every year, extreme weather strikes Indonesia, affecting a large number of people. According to [2,] Indonesia is one of the countries with the highest disaster risk in the world. For more than a century, nations have equipped themselves to provides weather, climate, and hydrological information, forecast, and more recently, remotely sensed data and early warnings to the public and private sectors [3]. They provide weather forecast information that is quick, accurate, straightforward, comprehensive, and widely disseminated, which people can receive through a variety of methods, such as a website or an application. However, it is not good enough, and extreme events continue to have numerous consequences for people because several problems in developing countries like Indonesia, such as a lack of communication systems and collaboration with many stakeholders, prevent them from providing appropriate weather information to their citizens. The Directors of National Meteorological and Hydrological Services (NMHSs) of the World Meteorological Organization (WMO) stated that the increase in global population, as well as the expansion of settlements and life-supporting activities in areas vulnerable to the impacts of weather-, climate-, and water-related disasters, makes it important to strengthen NMHS abilities, particularly in developing and least developed nations, in order to provide...
better services to reduce disaster risks and support national development and life-sustaining activities [4]. NMHSs are in charge of producing predictions and alerts for these occurrences in their respective national areas. As communication technology progresses and the media becomes more globalized, the public and many stakeholders will have more access to information about severe weather events, including warnings, from nearby NMHSs.

Unless this information is properly coordinated or even harmonized when possible, their effectiveness to motivate those at risk to take appropriate action may be reduced [5]. WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services says that within the WMO community, scientific advances in weather forecasting have afforded the ability to provide reliable warnings of hydrometeorological multi-hazards at accuracy and lead time that should directly fulfill the mission of NMHSs: to provide warnings of hydrometeorological hazards in support of the safety of life and mitigation of property damage [6]. Governments, economic sectors, and the general public must understand how hydrometeorological multi-hazards may affect their lives, livelihoods, and property, as well as the economy, in order to take necessary action. Impact-based Forecasting (IBF) will become one of the methods for providing meteorological information that is simple to comprehend. Exposure, as well as hazard and vulnerability, are explicitly considered in impact forecast and warning systems. These forecasts and alerts are intended to provide specific information about who or what is at risk. NMHSs (or the responsible government agency) must have specific vulnerability and exposure information related to the hazard and specific entities for whom (or whom) the forecasts are supplied in order to deliver these types of alerts. Impact forecast and warning services can only be provided in instances when NMHS has developed strong partnerships with other relevant agencies or with user communities [6]. IBF provides an assessment of the projected weather or climate hazard, as well as an assessment of the prospective impacts, including when, where, and how likely the impacts are, according to the collaboration IBF guide 2020 between UKMO and stakeholders. It also provides drives actions that save lives and protect property and livelihoods.

The UK Met Office is one of the meteorology agencies that has been successful in creating IBF in their country during the previous decade. They introduced impact-based warnings as a part of the National Severe Weather Warnings Service (NSWWS) in 2011. When severe weather has the potential to create consequences in the UK, NSWWS issues warnings based on the severity of possible impacts, including the likelihood of such impacts occurring. The study by Rebecca, et al. [7] displays the detail of warnings generated by the VOT model and the output on warning maps. They are simple to comprehend, with the impact risks on one map's legend and the goal of specific users. Unlike standard meteorological information, which is normally presented to consumers in text format, graphical messages are far more effective if the data gets displayed on a map. Indonesia has been working on IBF since 2018, and a representative from the Indonesian Agency for Meteorology, Climatology, and Geophysics (BMKG) presented at the WMO RA II Second Regional Workshop On Impact-Based Forecasts, The Impact Based Forecast Road Map for Indonesia (which contains six phases) extends until 2021, and the IBF paradigm change is in place in BMKG, which involves a strong link between forecasters and Disaster Management Agencies, at both the national and provincial levels.

This paper will show how to utilize ArcMap 10.8.1 software with a standard geospatial layout map for IBF and warning services. Guidelines for Implementation of the Common Alerting Protocol (CAP)-Enable Emergency Alerting [8] state that an originator or consumer of CAP format alerting information is typically interested in mapping hazard risks and incidents. The software allows the originator of an alert to draw an alert region on a map and outputs a set of latitude/longitude coordinates representing the area (in CAP, either a polygon or a circle). CAP-enabled applications and services include the ESRI GIS software, Google Maps, and Google Earth. This paper uses multi ensemble data from BMKG Head Quarter in raster format, National Digital Forecast (NDF) data from Pattimura Meteorological Station Ambon in Geospatial Information System (GIS) format, while also disaster data from the National Disaster Agency (BNPB), such as flooding risk, flooding danger, and flooding vulnerability area in Maluku Province. The method for this study is to create the prospective region using GIS basic and advanced analysis. After some analysis, these maps will be exported in picture and PDF file formats,
with detailed information such as the matrix, area, and legend for the matrix with sub-districts all contained on one map.

2. Data and method

2.1 Region of interest
Maluku is a province in eastern Indonesia that consists of 1,340 islands which cover a total area of 712,480 km², with 92.4 percent of the ocean and 7.6 percent of the land. Maluku Province becomes Indonesia's largest archipelago province due to its large number of small islands as its defining feature [9]. Maluku Province contains nine meteorological stations that provide daily weather information, with Pattimura Meteorological Station Ambon serving as the regional coordinator for public weather service in Maluku.

![Figure 1. Region of interest.](image)

2.2 Sources of data
The Pattimura Meteorological Station is responsible for gathering forecast data from all stations and entering it into the NDF system. We use data from the Pattimura Meteorological Station since it is quite precise and provides each sub-district in Maluku Province every three hours. The data is available in GIS format. Multi-ensemble data from BMKG headquarters, which is used to detect and forecast extreme weather events in BMKG. We use the mean multi ensemble model data with a high probability (80%-90%). The BNPB website has disaster data in GIS layer format for three types of data: flooding risk, flooding danger, and flooding vulnerability [10].

2.3 Method
In this study, we use ArcMap 10.8 and two techniques. There are two types of analysis: fundamental analysis and advanced analysis. GIS will empower you to build maps, integrate data, visualize scenarios, solve complex problems, present compelling ideas, and build practical solutions in the same way it did historically, allowing you to assist in strategic decision-making. We can use the GIS application to access digital maps on a computer, add new spatial information to a map, print customized maps, and perform geographic analysis. There is a lot of geographic data out there in forms that cannot be combined with other GIS data instantly. Firstly we should extract data from BNPB and BMKG headquarters to a
shapefile format. We were using fundamental analysis for digitizing flooding data from BNPB because the data still in layer GIS format data. Digitizing data use an editor panel with freehand drawing and select just only the high potential area and save it on to shapefile format data. Extract the multi ensemble data into raster data with spatial analysis tools and classify the data, then save it in raster format data. We export the data to a polygon using conversion tools, then save it on to shapefile format data. Now, we have two data in shapefile format data. Secondly, using NDF data from Pattimura Meteorological Station Ambon in shapefile format to compare and make the potential heavy rain area using scoring data analysis. From that potential area, we will analyze disaster data from BNPB to get a final area of interest in shapefile format. Finally, we will set the maps for IBF map information with the standard format in GIS.

3. Result and discussion

3.1 Disaster data analysis

Disaster data analysis uses fundamental analysis with manual digitizing method because the format data is in GIS layer format (Figure 2). It displays the flooding risk in the Maluku area in three indicator colors, which are red (high potential), yellow (medium potential), and green (low potential). Many areas in the green indicator in Maluku Province and just a few areas show indicators with medium and high potential flooding risk. Digitize the flooding risk map using freehand and save the data in shapefile format to eliminate a low risk of flooding in that area (Figure 3). Figure 2 shows the result of digitizing with medium and high area in the red colors. With this technique, we can easily detect and determine where an area has high risk when heavy rain occurs.

Figure 2. Flooding risk maps of Maluku Province.
3.2 Multi-ensemble model and NDF data analysis

Figure 4 displays multi ensemble data in raster format. It cannot be calculated in ArcMap since the data is not a polygon form, so an advanced method is used to convert raster data from multi ensemble model data to polygon, allowing the data to be combined with other data in a shapefile.

In figure 5 shows the data extracted by advanced analysis in ArcMap used conversion tools. It displays the three categories from low until high indicating from multi ensemble models data. The areas with medium and high probability in Maluku Province are Seram Island with (detail districts: Maluku
Tengah, Seram Bagian Barat, Seram Bagian Timur), Buru Island (detail districts: Buru Selatan, Buru) and Aru Island (detail districts: Aru Utara, Sir-sir, Pulau-pulau Aru, Aru Utara Timur), using the conversion tools to select just indicating area in 80 - 90% (Figure 5).

Figure 5. Converting of multi-model ensemble.

Figure 6. Ensemble model of heavy rainfall area.

NDF data from Pattimura Meteorological Station (Figure 7) displays moderate and heavy rainfall locations based on the weather forecast, indicating areas in Ambon and Seram Island with the high potential heavy rainfall. Figure 8 is comparing data between NDF data and multi ensemble data using analysis extract tools. This technique is appropriate to detect shading areas. The shading area is the
primary area to become the base IBF map after calculating a range with spatial flooding risk data (Figure 2).

**Figure 7.** Potential heavy rainfall area from NDF.

**Figure 8.** Heavy rainfall area from two data (Ensemble and NDF).
Finally, in figure 8, after comparing two data (figure 6 and figure 7) then using analysis extract tools with clip method, the result of area IBF is showing. After that, we can easily calculate the indicating sub-district areas with joined spatial analysis. It can show the impact area in the IBF map product.

Figure 9. The final potential area from three data.

3.3 IBF Map
Figure 9 displays the IBF map products in Maluku Province. It has a standard GIS map format with title, insert area, legend, validity of time, warning detail (warning issued, affected area, impact, which must be done, and impact matrix) that is very detailed and straightforward, easy to understand. The Indicating area shows the result from Figure 8, but two impact categories are the yellow one (Be Aware) and the orange one (Be Prepared).
4. Conclusion

Finally, combining three data sets such as disaster data, multi ensemble model data, and NDF data into the IBF map using ArcMap 10.8.1 with basic and advanced analysis is the best solution. The layout format, which uses the standard GIS format, conveys excellent information to users and stakeholders who require specific weather event information that is not only fast, but also accurate, and widely available. However, it should be precise and easy to understand.

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