Turkish State Meteorological Service Radar Network Feasibility Studies

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Abstract:

Turkish State Meteorological Service has been planning to expanding its existing radar network of four radars by installing new ones in required sites. A feasibility study for determination of the number, type and location of the new radars has been under process for last two years.

1. Introduction:

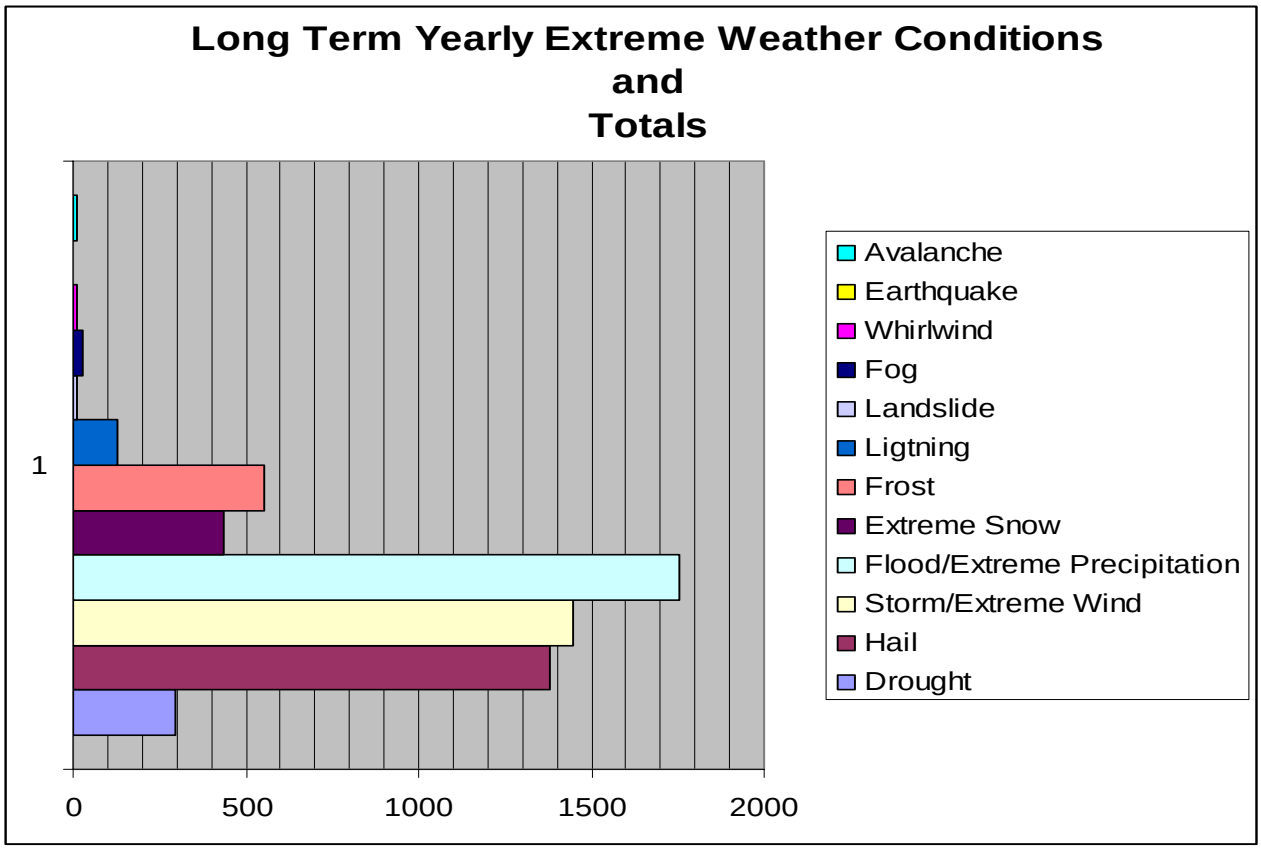
Extraordinary weather conditions like extreme precipitation, hail, storm, hurricane, drought, avalanche causes natural disasters. One of the most important component to prevent this natural disasters or to reduce damage is establishing observing systems and early warning systems, informing authorities and public in time. Especially, now casting meteorological events like storm, extreme precipitation and hail with a effective observing and early warning system can reduce damage of natural disaster.

Meteorologists and Hydrologists needs precipitation data. To get reliable data is too difficult in contrary it seems very easy. Rain gauge measurements have some errors according to the measurement device and place. A 200 cm^2 surface represents almost 100 km^2. If regional difference in flood conditions considered, point measurements are quite prejudiced even if the measurement is correct for that point. For this reason Meteorologists and Hydrologists focused radar measurements for now casting and flood forecast. Radar provides monitoring of distribution of instant precipitation intesity on big areas. It also have some calibration problems like unknown attenuations, ground clutters, beam blockages, so they are semi-quantitative devices but radars are best methods for gathering precipitation.

The products gathered from weather radars will be used for now casting, area of aeronautical meteorology and hydro-meteorological works. Based on this point, the products expected from radars are:

1) Now casting Products
2) Aeronautical Meteorology Products
3) Hydro-Meteorological Products
4) Research/Development and General Purpose Products

If weather radar network and early warning systems establishes parallel to the applications of preventing disaster and reducing damage similar to developed countries, it can be evaluated as an expectation that the material loss can be saved at least %50 and life loss can be saved at least %70. The most frequent extreme weather conditions are Flood/Extreme Precipitation, Storm/Extreme Wind and Hail. Most of this extreme weather conditions can be detectable by an effective radar network.






Some pictures of natural disasters because of extreme weather conditions in Turkey

The first step of the each activity is always very important. So, the site selection and determination of the infrastructure requirements at the design stage of the radar network is very critical and affect the overall success of the network operation seriously. All issues regarding the operation of the radar network should be evaluated by considering the data and services expected from radar network. Meteorological evaluation, e.g. rainfall and flash flood, radar coverage, big settlements areas, existing infrastructure and the requirements, communication options for data transmission, etc. should be done by the experts.

A complete review and design of a weather radar network must begin with an analysis of the rainfall and flood producing weather systems and the applications for which the radar network is being installed. For example, hail, tornadoes, thunderstorms, and orographically enhanced rainfall would become all present different problems and may require different hardware configurations. While it is relatively easy to measure thunderstorms with weather radar, winter rainfall in a mountainous region represents the worst case scenario due to difficulties

with ground clutter, the shallow nature of the rainfall, occultation of the radar beam, and possible orographic enhancement at low levels.

The terrain covered by the radars is generally very rough, and this forces the use of high, relatively isolated, hills as radar sites. This, together with the need to scan at low elevation angles due to bright band and orographic rainfall considerations, means that ground-clutter may be a major issue for the network. There are several strategies that can be used to minimise the effect of ground clutter including the use of a narrow beam, rejecting the pixels that have clutter on fine days, and using the statistical characteristics of the individual pulses.

2. Basic Components and Subjects of the Feasibility Study

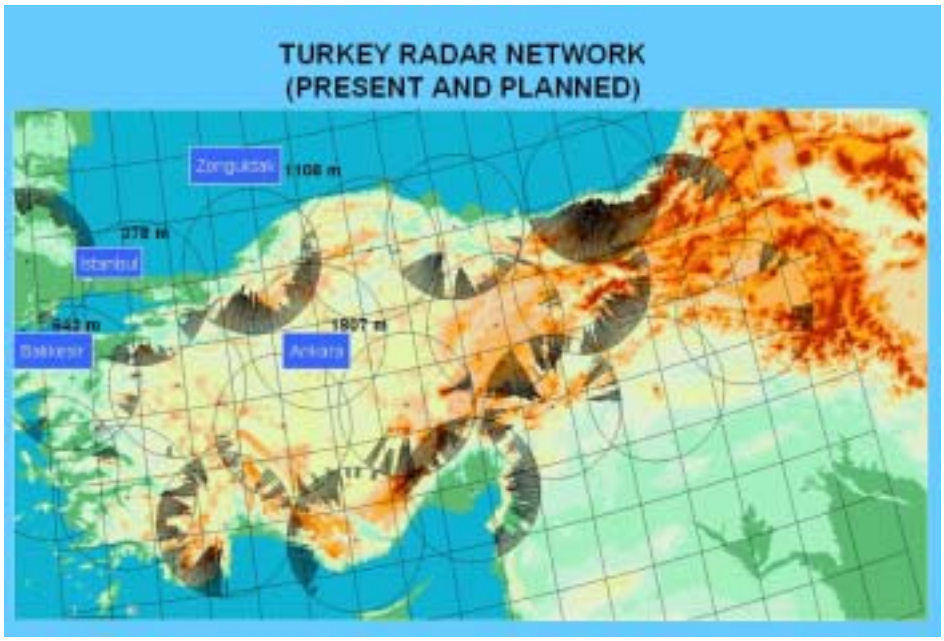
Feasibility study has been performed by considering some critical issues as follows:

2.1. Radar Site Selection Criteria

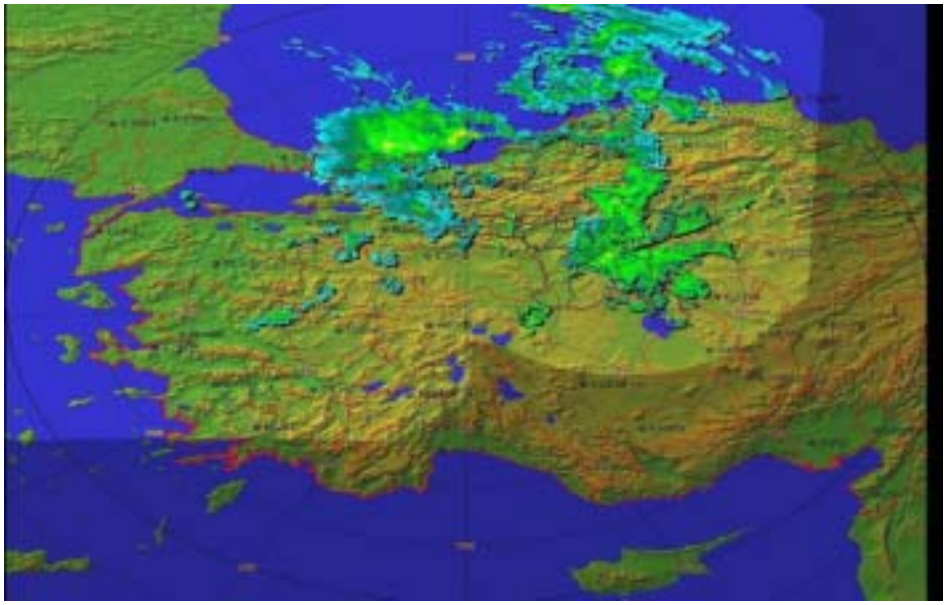
As stated above, there are some critical issues to evaluate while determining the site for installation radar. These are described briefly as follows:

Radar coverage can be defined simply as the area in which radar beams can travel to detect the targets without any blockage. Radars are used for the large scale monitoring of the weather phenomena. So the radar beam should scan a large area as much as possible and the site selection must be done by considering the radar network concept. A part of the area which can not be covered by one of the radars in the network can be covered by another radar of the network. So all required area would be under coverage of entire network.

Mostly weather systems come into Turkey from North West Region (the Balkans). This region is covered by four weather radars. Other regions, especially coastal regions and the regions have high risk of flood occurrence should be included to radar network coverage. In the scope of radar network feasibility study, a lot of probable radar sites have visited and coverage analysis executed.

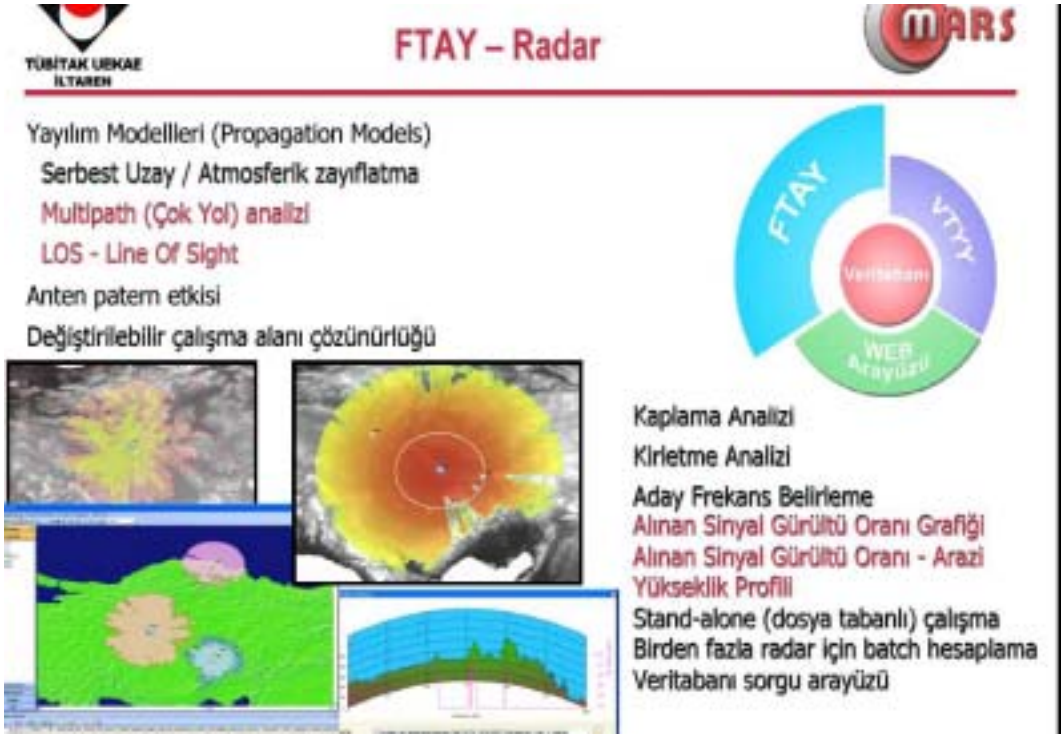


A coverage analysis of Radar Network of Turkey for long term plan

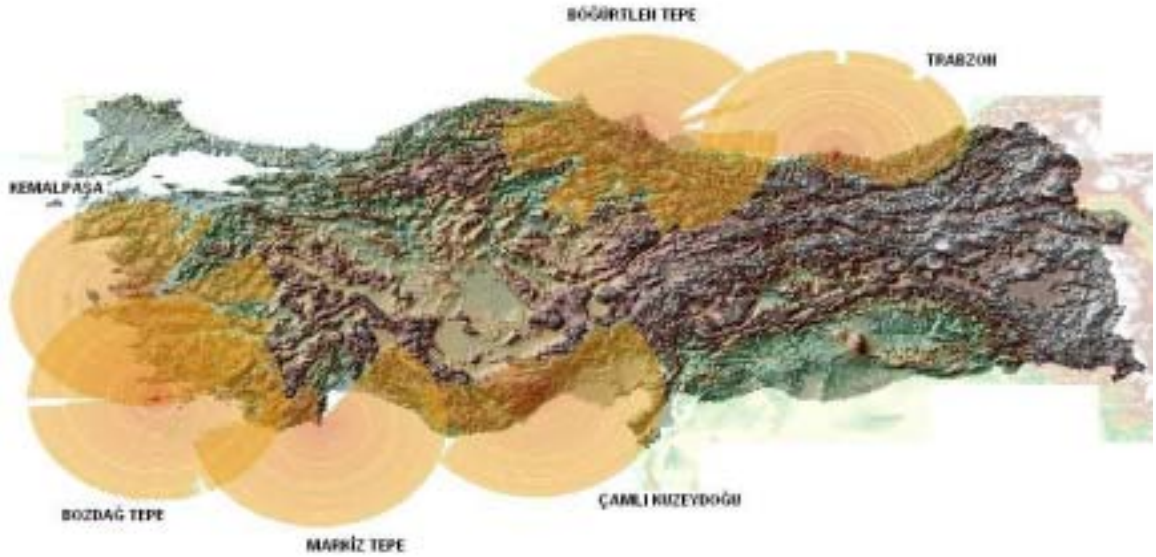


Coverage of present radar network of Turkey

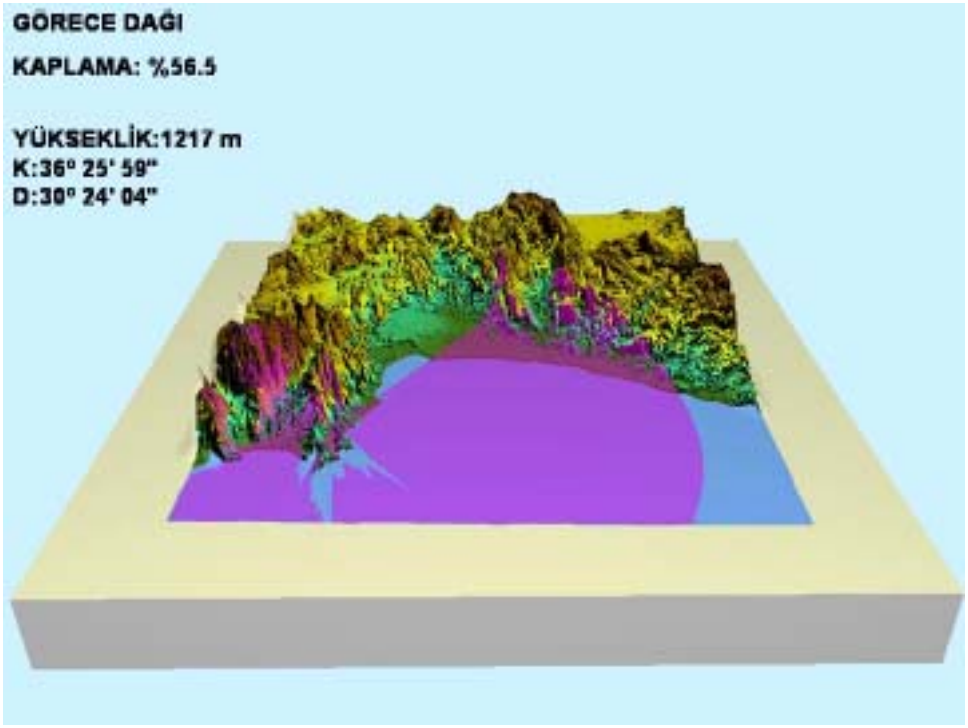
There is **special software** available to make radar coverage analysis by means of digital terrain elevation data of high resolution. Some examples of radar coverage analysis are given below.



The software developed by **The Scientific & Technological Research Council of Turkey (TUBITAK)** is used by TSMS for radar coverage analysis. It is possible to make a cross section analysis for a given angle with this software for specific radar.



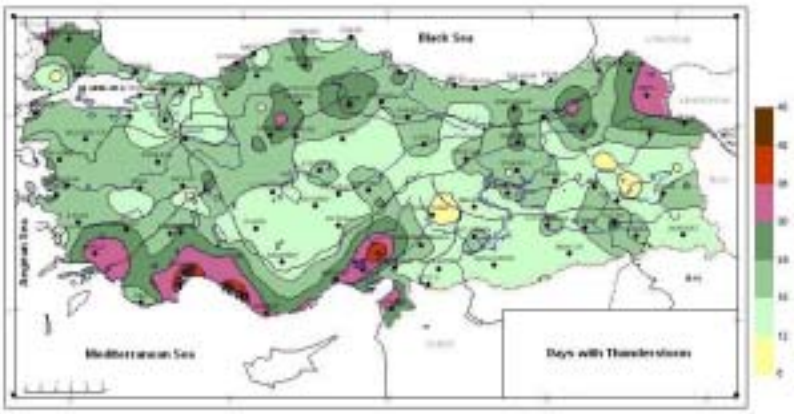
A coverage analysis pictures of radar network to be establish in the scope of short term plan



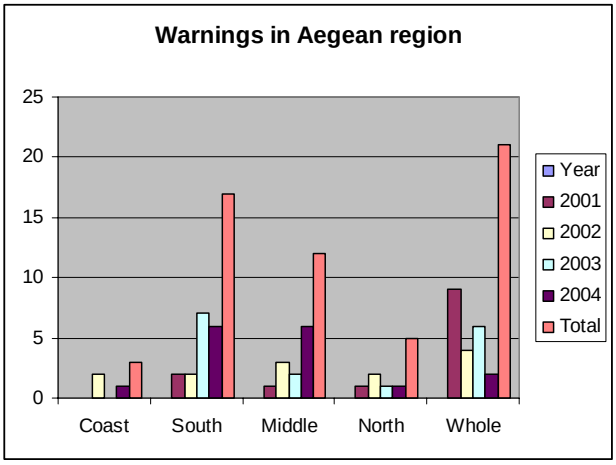
A 3-D radar coverage image from another application

The meteorological phenomena to be monitored by radar network should be also evaluated very carefully within the radar coverage area. The general approach to the design of an appropriate radar network was therefore to understand the applications for which the data are being collected, to assess the suitability of the proposed network in light of the meteorology of the area and to assess the level of experience in radar measurements prior to starting a detailed specification of the radar hardware.

An example of this analysis is to map the regions according to the extreme weather conditions. We can see the regions according to the **thunderstorm frequency** on the map below.



Another example is the analysis of **warnings realized in the regions of Turkey**. The most frequent extreme precipitation warning in Turkey between 2001 and 2004 realized in the Aegean Region. The south part of Aegean Region has most frequent warnings of extreme precipitation. The radar network in this region is important for now casting and verification of forecasts.



Aegean Region of Turkey					
Year/ Part	Coast	South	Middle	North	Whole
2001		2	1	1	9
2002	2	2	3	2	4
2003		7	2	1	6
2004	1	6	6	1	2
Total	**3**	**17**	**12**	**5**	**21**

On the other hand, **electromagnetic compatibility (EMC)** analysis should be performed to determine the suitability of the site on the basis of interference between the radar and other types of radio/radar services, and human exposure to the transmitted radar beam. Such analysis should identify the operating frequency and the power of the radar. Furthermore, the location, frequency and power of other radio services that are either potential sources of interference for the radar, or that the radar has the potential to interfere with should be identified. Human exposure to the radar beam is rarely a problem, but it should still be considered.

Other parameters like **radar type** and **data archiving** considered in scope of feasibility study. These parameters considered according to the cost, existing experiences and criterias mentioned above like regional meteorological parameters. C-Band was evaluated as the best band type for Turkey's region as existing radar's bands. Some of the reasons are as following: C-Band Radars have better resolution than S-Band because of its smaller wavelength, so they can detect smaller particles. Generally their maintenance is easier and their price is cheaper then S-Bands. They have better range than X-Bands. Also more cost effective than X-Bands with their ranges.

2.2. Radar Infrastructure Requirements

Tower: In some cases, a tower of certain height is required to install the antenna and radome on the top of it.

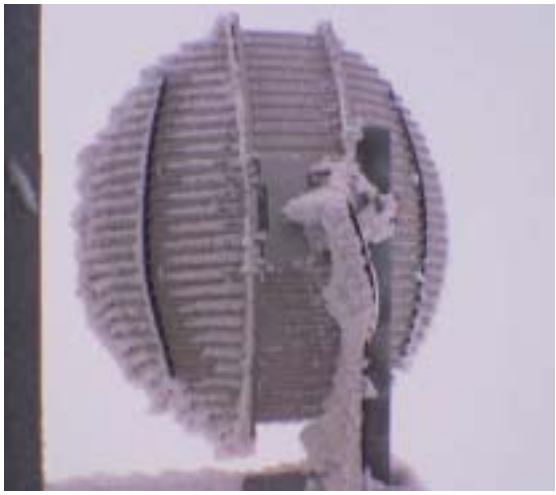
Power Supplies, the proximity of the radar site to the **main power lines** should be considered. Power transmission and Back-up power supplies should also be taken in to account.

Lightning Protection & Grounding

Lightning is the most dangerous and hazardous event for radar sites. An effective lightning protection and grounding system should be designed and installed based on a very detailed analysis of the site conditions.

Communication & Network, There must be a permanent communication system between radar site and operation center. This can be managed several ways like:

Terrestrial line, fibre optic cables, satellite and microwave data link can be optional communication methods..



A land survey should be performed to accurately determine the boundaries of the radar site land area, the location of the entrance road to the site, and the location of any required easements for access to the radar site property. The survey should also determine water runoff and drainage of the radar site area.

Soil tests should be performed to determine the load bearing capacity of the soil for the foundations for both the radar building and for the radar antenna tower. These soil tests should serve as the basis for the design of the building and tower foundations.

Access road is also very critical issue for the operation of radars. Access roads should be available or constructed/ improved by considering the need of the access to the radar sites in any weather conditions. Appropriate vehicles should be supplied according to the conditions.

Fire Alarm System should be installed with a capability of remote indication via the radar communications system. This alarm system should be located in the equipment room and also

at the personnel building. Automatic fire extinguishers should be available in the equipment room.

Heating and air conditioning system is needed for keeping the stability of the temperature at the equipment room. It is also necessary for the personnel accommodation.

The security requirement should also be taken into consideration against possible risks.

3. Conclusion

While radar network is an important and critical issue, before widen existing radar network, a feasibility study should have been carried out. It is evaluated during the feasibility studies that establishing eleven more weather radars in addition to existing four radars will provide an effecting radar network. Especially coastal regions and the regions have high risk of flood occurrence should be included to radar network coverage by this expansion. The studies on the expanding the radar network started after the feasibility study.