Methods for Forecasting, Assessing and Mitigating Avalanche Risks

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Abstract— The main aim of this study is to develop an avalanche prediction method, based on the previously available accidents data, metrological data and related location conditions. Methodology is applied to the sample weather data inputted in the avalanche utility software through Microsoft's excel sheets. Application is given for forecasting avalanches. Avalanche forecast is based on the observation of weather conditions and follow-up snow cover or avalanche prone areas. We will present how the forecasters can select amongst the high number of views the most relevant ones according to the day situation. We will also describe the main contributions and work of the models for different typical situations. This avalanche forecasting models is based on statistical analysis. This study also deals with to generate awareness in the aspect of avalanche mitigation, protection and reduces damage in this work we have adopted various methods of avalanche control, protection, mitigation and assessment these methods are very helpful in avoidance and minimizing to avalanche threats.

Key words: Avalanche Rating Calculation Formula, Development Of a Model for Avalanche Forecasting, protection

I. INTRODUCTION

In India avalanches have long posed a threat and risk to originating population of the Hilly area specially Uttarakhand, Himachal Pradesh, J&K and Sikkim. Now a day's avalanches accidents happen primarily to people during recreational pursuits, and about half of victims over the last many years. In general, avalanches are caused when balance is lost and when the frequency exceed the resistance avalanches are rarely observed closely since they normally occur during a short time period of one or two minutes avalanches form as soon as the force of gravity on the snow cover exceeds its mechanical strength to be caused, an avalanche needs a steep slope, snow cover, a weak layer in the snow cover, and a trigger to initiate movement snow does not accumulate significantly on steep slopes also, snow does not flow easily on flat slopes. Convex slopes are more susceptible to avalanches than concave slopes. Factors are combined Avalanches are one of the major geological threats in the Himalayan belt. On a global scale, the South Asian region, Europe, Australia and New Zealand is one of the hot spots of avalanches and associated slope failure phenomena. Masses of snow-and ice crystals admixed with air descending from mountain top at very high speed and flowing like rivers of snow and ice blocks in the valley below are known as avalanche.

II. OBJECTIVE

To study about the avalanche forecasting, assessing and mitigating avalanche risks and the focus is on terrain selection and group management in terms of avalanche risks. A discussion of the possibility of rule based decision methods in terms of avalanches control, avalanche education and remedial measures. Analysis of avalanche risk factors in terms of terrain the analyses based on various instructions and organizations data like NIDM, SASE and **www.Avalanche-Center.org** etc. Data Extraction of knowledge from professionals regarding avalanche risks management and try to developed statistical analysis model for avalanche forecasting.

III. LITERATURE REVIEW

A.Ganju and A.P.dimri (2002). They studied about Prevention and Mitigation of Avalanche Disasters in Western Himalayan Region. In this paper they discuss the cause of avalanches, the magnitude of their destruction power and the techniques followed in India by the Snow and Avalanche Study Establishment (SASE), a DRDO Laboratory, for mitigating avalanche disasters in Western Himalayan Region for the defense forces. The authors suggest that an integrated plan for mitigating the avalanche disasters should be set up at national level, involving defense forces and state governments. There is also a requirement for improving the accuracy of avalanche forecasting by developing avalanche-forecasting models for different areas. If models are to produce accurate results, there is a need to enlarge the observatory network (Automatic Weather Station based). For projected weather conditions there is a requirement to develop a Quantitative Precipitation Forecast (QPF) model. And finally, there should be some national policy for creating well equipped and trained Avalanche Safety and Rescue Organization.

G.B.Crosta et al., (2006). They studied about Forecasting hazard scenarios and implications for the evaluation of countermeasure efficiency for large debris avalanches. They assessed the design criteria for passive counter measures are lacking, and very often the working conditions are also unknown. Regardless of the uncertainties and variations, the most important parameters necessary to the reasonable design for all mitigation structures are those of a kinematic type are debris moving velocity, maximum discharge or hydrograph and volume. Also, designs of mitigation structures are very site specific and must include both the character of the subject event, and the run out path and deposition zone. One of the important tools for mitigation structure evaluation is a mobility analysis of the entire run out process, which may not be used to estimate the hazard zones in potential debris released areas and the dynamic parameters during run out.

IV. DEVELOPMENT OF A MODEL FOR AVALANCHE FORECASTING

For individual or group, with requirement of avalanche forecasting of different avalanche zones, show travel advices, avalanche advisory and weather details; this tool can be used as "Avalanche Forecasting Utility". As it can be configured for forecasting of different zones, based on

statistical forecasting specific dates, use real time weather conditions and generate summary report. This also helps to categorize avalanche rating and danger in five levels automatically. It doesn't require any manual calculation to perform the forecasting activities. It is completely based on statistical analysis.

V. PROPOSED SOLUTION

Automated the process using VB(C#/.NET) application for avalanche forecasting on a single click. The Avalanche Forecasting Utility is the light weight windows application for forecasting of different avalanche zones, show travel advices, avalanche advisory and weather details. Only the analysis sheet required to perform the forecast activities.

A. Easy to operate:
Forecasting utility is user friendly software to forecast the avalanche danger with a simple and easy to operate GUI.

B. Multiple Details At The Same Time:
Details like avalanche advisory, weather details, avalanche danger, recent avalanche activities, travel advice, avalanche rating and level can calculated on a click.

C. Configurable:
The tool can be configured to forecast for different avalanche zones.

D. Categorization:
The tool categorizes avalanche rating and danger in five different levels of avalanches.

E. Results:
It will forecast the avalanche danger and create a summary report in .txt format. The text file contains forecast date, advisory, weather details, travel advice, avalanche danger and rating.

VI. AVALANCHE RATING CALCULATION FORMULA

To calculate avalanche rating below formula has been used, using month wise avalanche ratings, weather rating for that place and rating for forecast time.

S.No.	Avalanche Rating(R_{av})	Description
1	$1 <= R_{av} <= 4$	Avalanche Danger is Extreme
2	$4 < R_{av} <= 7$	Avalanche Danger is High.
3	$7 < R_{av} <= 11$	Avalanche Danger is Considerable
4	$11 < R_{av} <= 14$	Avalanche Danger is Moderate.
5	$14 < R_{av} <=21$	Avalanche Danger is Low.

Table 1.1: Avalanche Rating

$\mathbf{R_{av} = (R_{ma} + R_w + R_t)}$
Here, $\mathbf{R_{av}}$ = Avalanche Rating;
$\mathbf{R_{ma}}$ = Month wise Avalanche Rating;
$\mathbf{R_w}$ = Weather Rating;
$\mathbf{R_t}$ = Time Constraint Rating;

VII. DANGER LEVEL

Avalanche Danger	Rating	Symbols	Avalanche Advisory
1. Extreme	1 to 4		Avoid all avalanche terrain.
2. High	5 to 7		Very Dangerous avalanche condition. Travel in avalanche terrain not recommended.
3. Considerable	8 to 11		Dangerous avalanche condition. Careful snowpack evaluation, cautions route-finding and conservative decision making essential.
4. Moderate	12 to 14		Heightened avalanche condition on specific terrain features. Evaluate snow and terrain carefully, identify features of concern.
5. Low	15 to 21		Generally safe avalanche conditions. Watch for unstable snow on isolated terrain features.
No Rating	0		1. Insufficient information to establish avalanche danger rating. 2. Weather information not available in Database
For More Information try : Avalanche Forecasting Utility			

Table 1.2: Danger Scales of Avalanches

VIII. SOLUTION FLOW DIAGRAM:

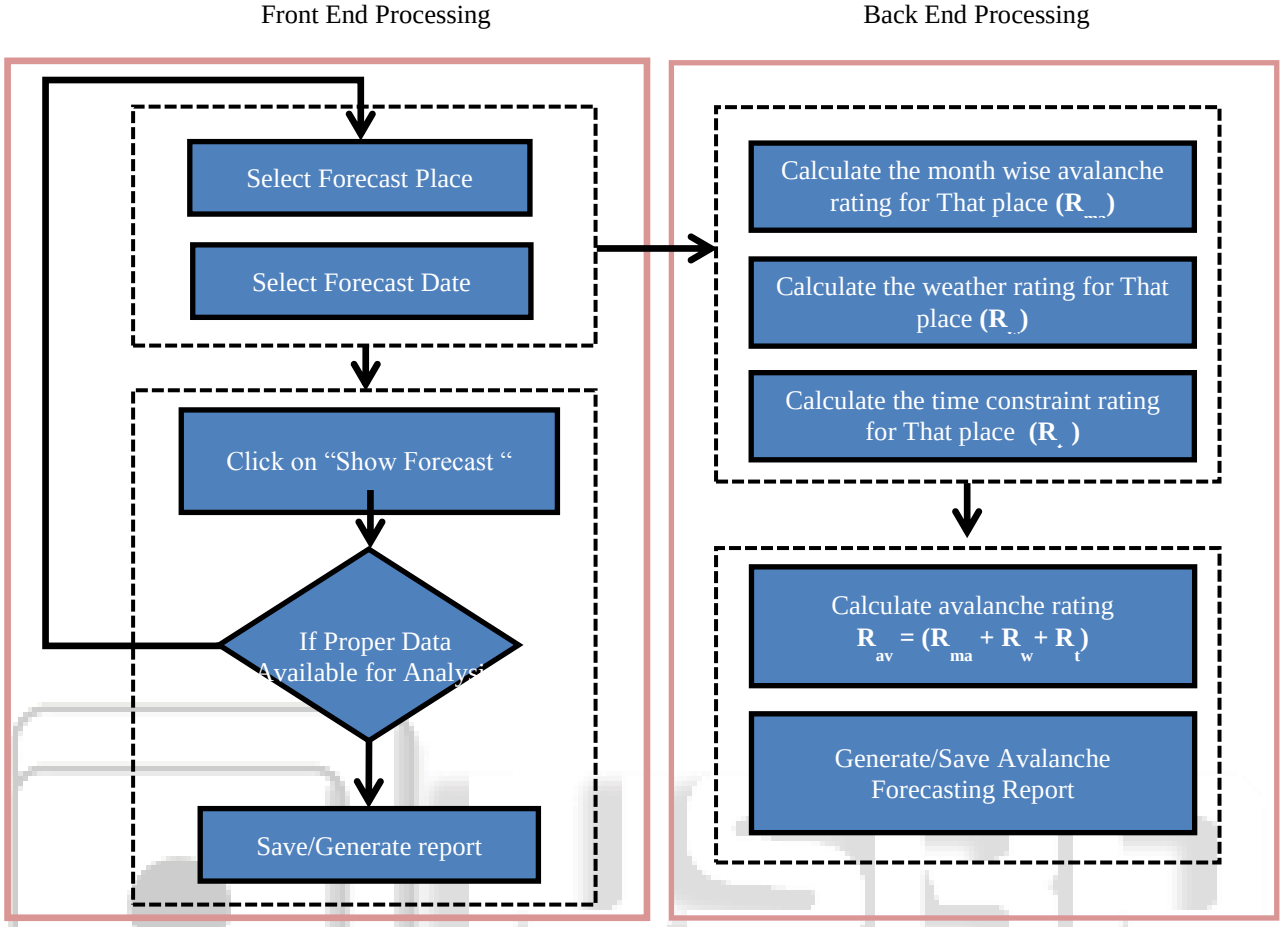

Fig. 1.1: Flow Chart Of Utility (Working Mechanism

IX. KEY FEATURES:

- User-friendly GUI
- Use real time weather conditions from input data.
- Option to choose desired forecast place.
- Option to forecast for any specific date.
- Output Summary Report for each forecasting in .txt file.
- Categorize avalanche rating and danger in five levels.
- Configurable for forecasting of different zones.
- Calculates and provide rating for a particular day based on statistical forecasting techniques.
- Use previous year avalanche data and statistics for forecasting.
- Categorize avalanche rating and danger in five levels.
- List out travel advice, recent avalanche activities and weather details.

X. SOME ADDITIONAL FEATURES:

- Configurable for forecasting of different zones.
- Calculates and provide rating for a particular day based on statistical forecasting techniques.
- Show/Hide option to check analysis data.
- Option to Save/Generate Summary Report.

XI. SAMPLE ANALYSIS DATA:

Place	Date	Temperature	Details	Weather
Gulmarg	06/Sep/2014	18/8°C	Partly cloudy in the morning followed by scattered thunderstorms in the afternoon. High 18C. Winds light and variable. Chance of rain 50%.	Rain

Gulmarg	07/Sep/2014	19/7°C	Mostly sunny early. Scattered thunderstorms developing later in the day. High 19C. Winds light and variable. Chance of rain 60%.	Rain
Gulmarg	08/Sep/2014	18/8°C	Mostly sunny skies during the morning hours will give way to occasional showers in the afternoon. High 18C. Winds light and variable. Chance of rain 50%.	Rain
Gulmarg	09/Sep/2014	18/8°C	Mostly sunny early. Scattered thunderstorms developing later in the day. High 18C. Winds light and variable. Chance of rain 40%	Rain
Gulmarg	10/Sep/2014	19/7°C	Sunny. High 19C. Winds light and variable.	Clear
Gulmarg	11/Sep/2014	19/7°C	Sunny. High 19C. Winds light and variable.	Cloudy

Table 1.3: Sample Analysis Data

XII. PROCESS TO GENERATE AVLANCHE FORECSTING REPORT

A. Open Avalanche Forecasting Utility:

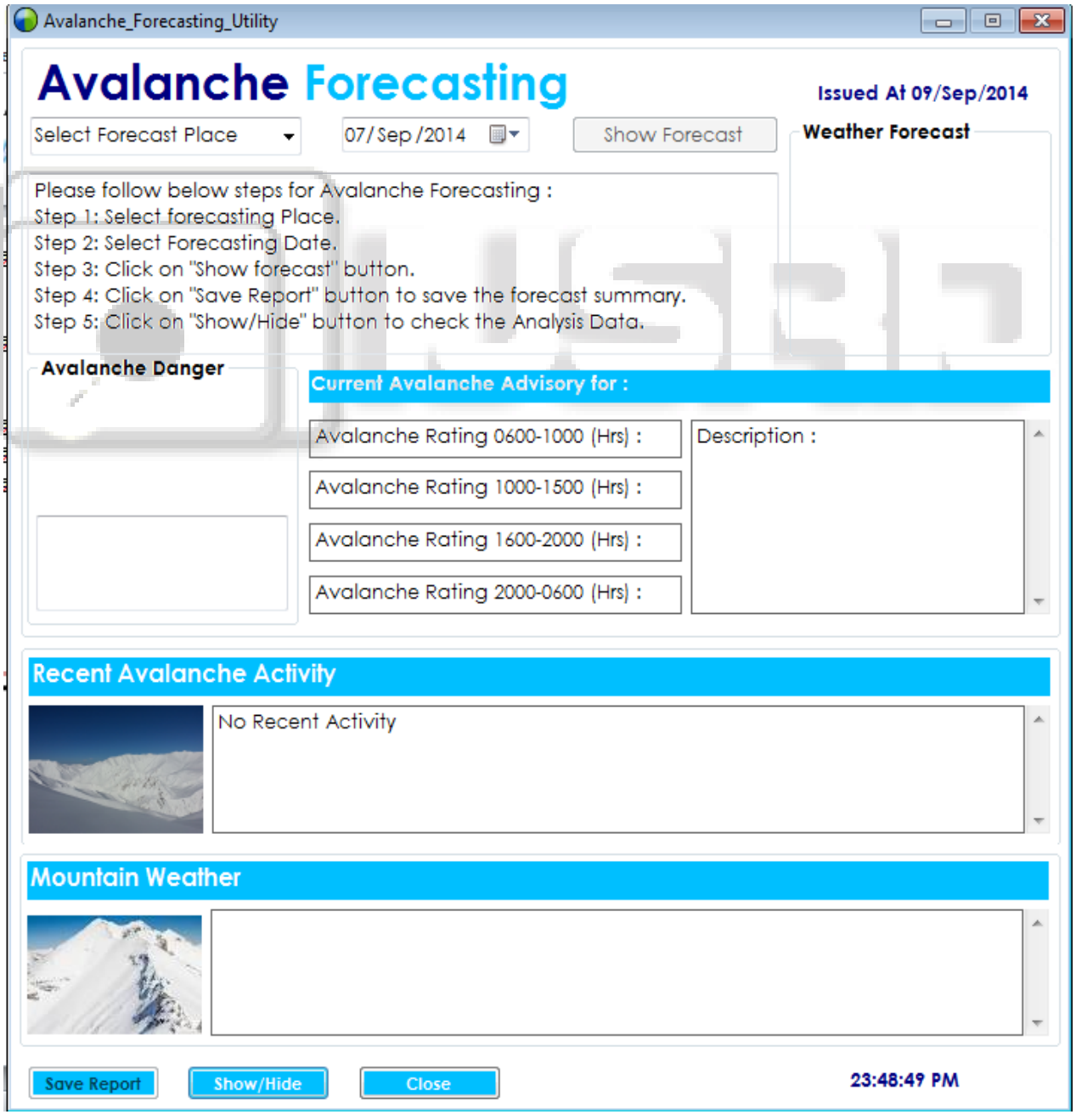

Fig. 1.2: Screen Shot Opening of Tool Utility

B. *GO TO "Select Forecast Place" Box And Select Desired Place (Gulmarg Below 3000) For Forecasting:*

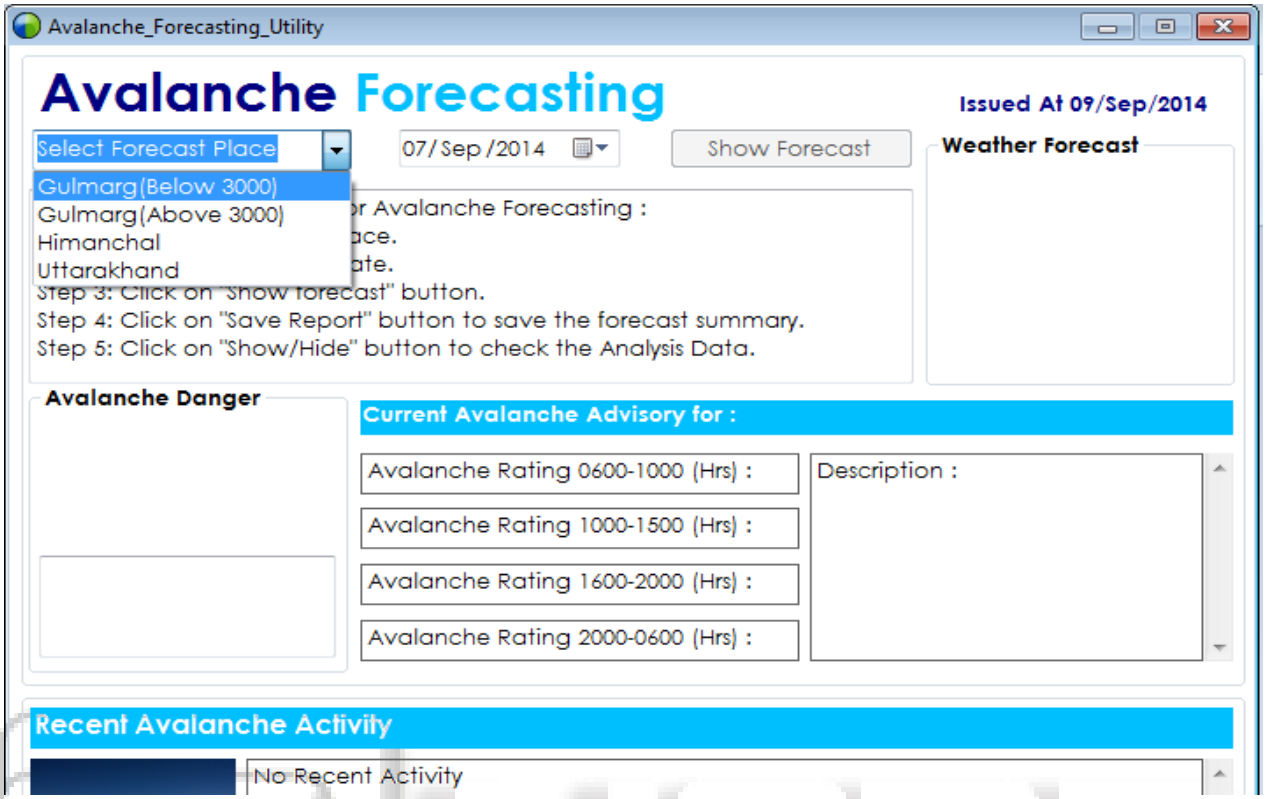

Fig. 1.3: Screen Shot of Selected Place for forecasting

C. *GO TO "Calendar" Box And Select Specific Date (09/09/2014) For Forecasting:*

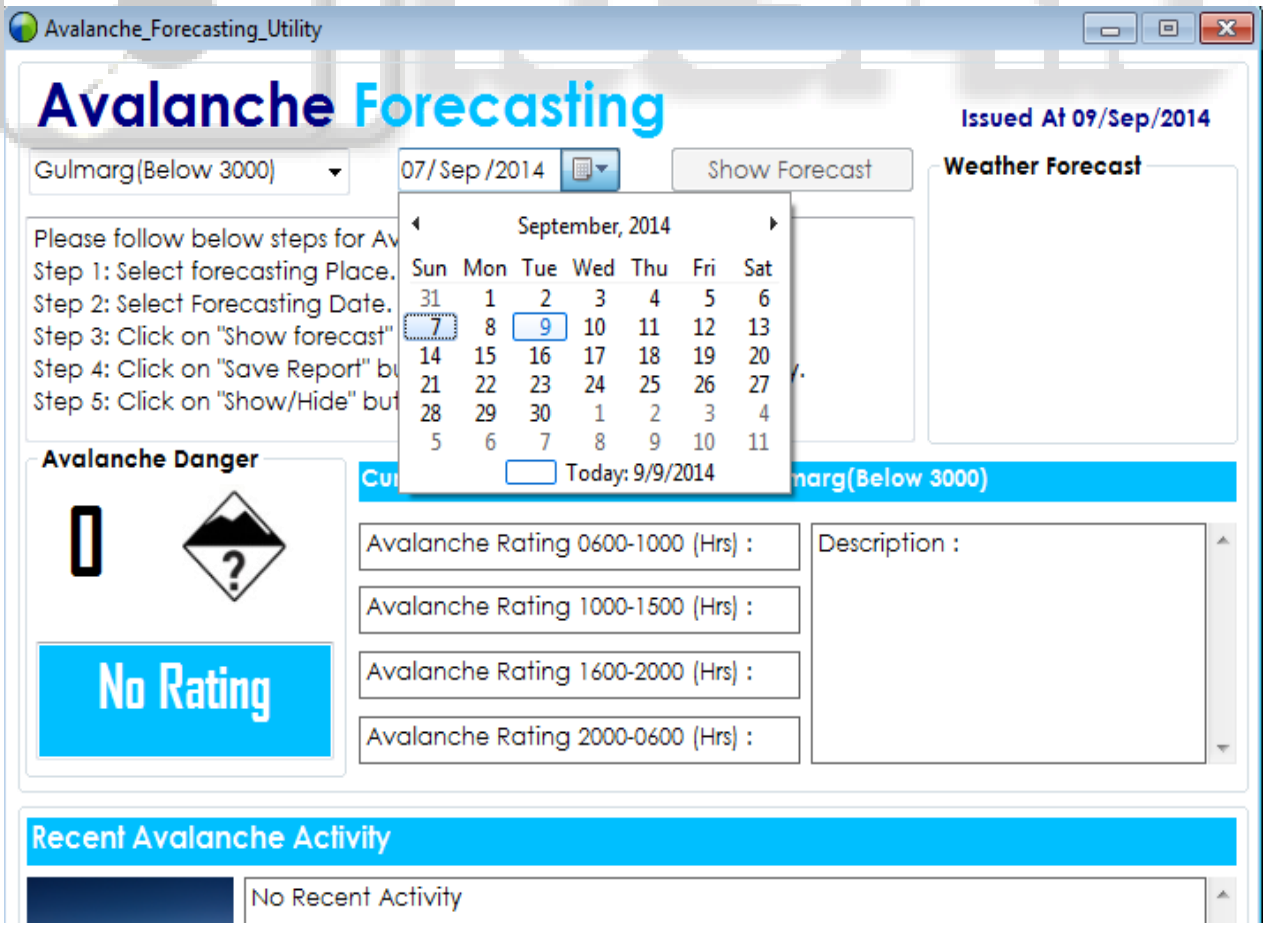

Fig. 1.4: Screen Shot of Selected Date for Forecasting

D. Click On "Show Forecast" Button To Generate Forecasting Report:

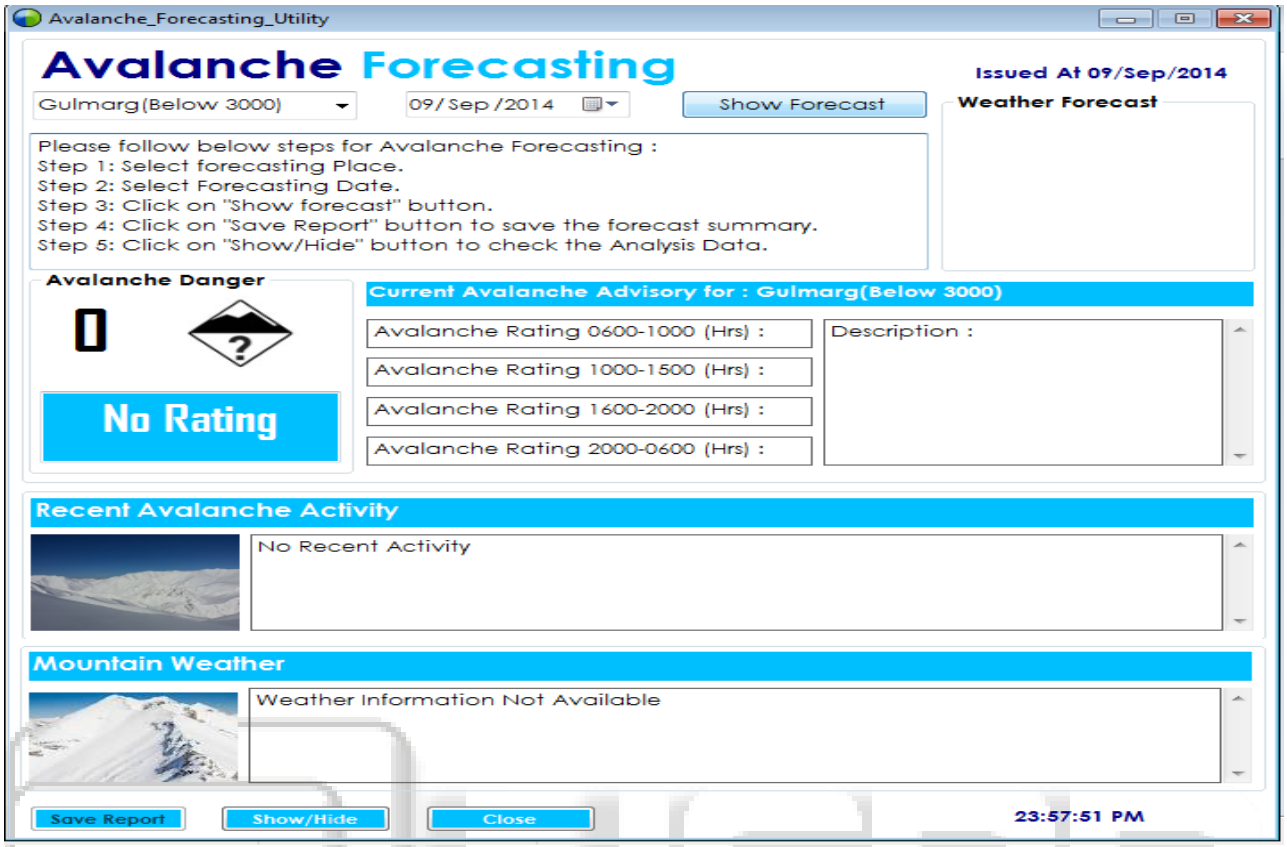

Fig. 1.5: Screen Shot for Generate Forecast Report

E. You Will See The Forecast Report And Other Details:

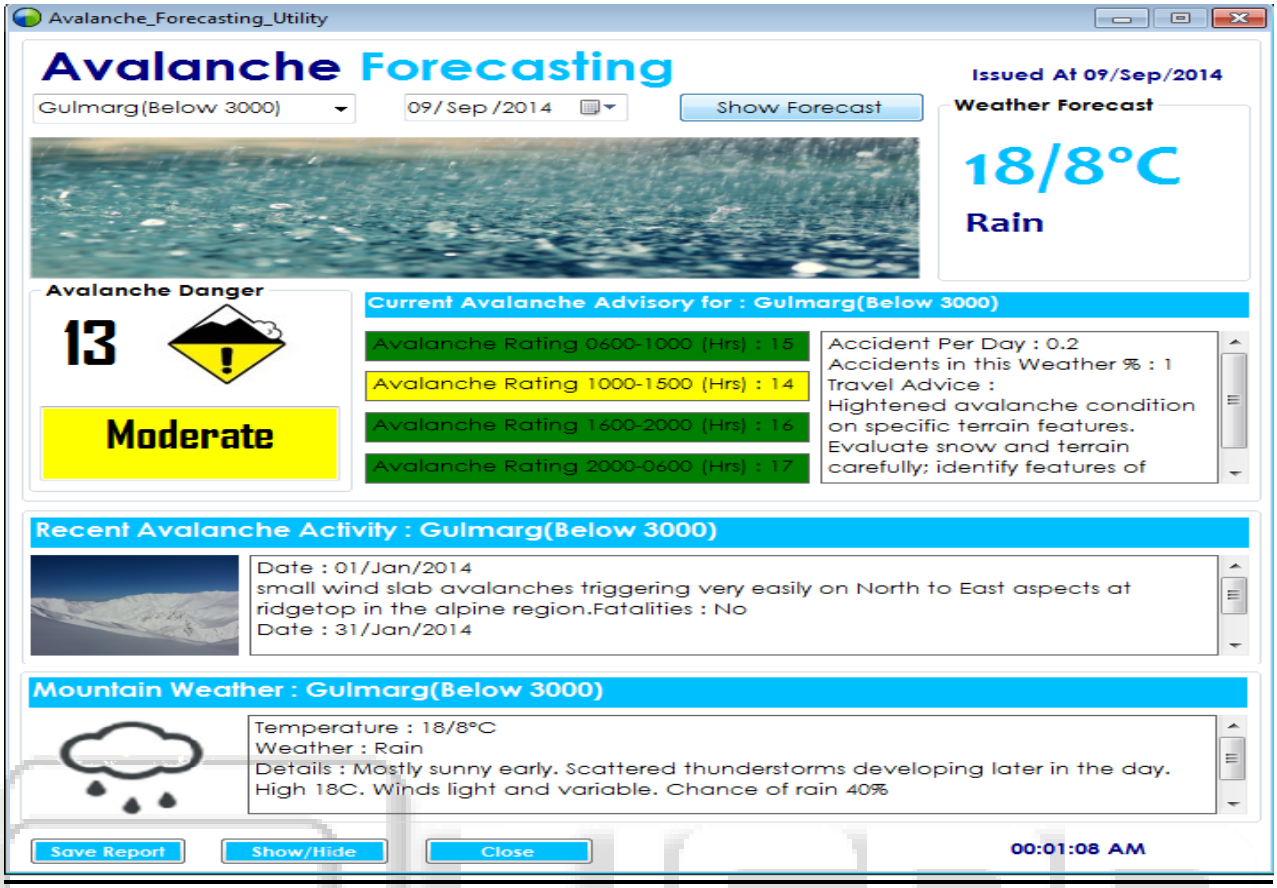

Fig. 1.6: Screen Shot of Report Generated

F. Summary Report Format And Content:

1) File Name:

Avalanche_Forecasting_MMddyyyyHHmmss_Summary_Report.txt

2) File Type:

Text File (.txt)

3) File Data:

/*****Start Of Report*****

Summary Report Name : Avalanche_Forecasting_09082014_Summary_Report.txt
Avalanche advisory For : Gulmarg (Below 3000)
Forecast Date : 03/Sep/2014
Avalanche Rating : 13
Avalanche Danger : Moderate
Accidents Per Day : 0.2
Accidents in this Weather % : 1
Temperature High/Low (ºC) : 13/8ºC
Weather Condition : Rain
Weather Details : Rain showers in the morning with thunderstorms.
Travel Advice : Hightened avalanche condition on specific terrain features.
Autogenerated Summary Report by Avalanche_Forecasting_Utility Tool.

*****End of Report*****/

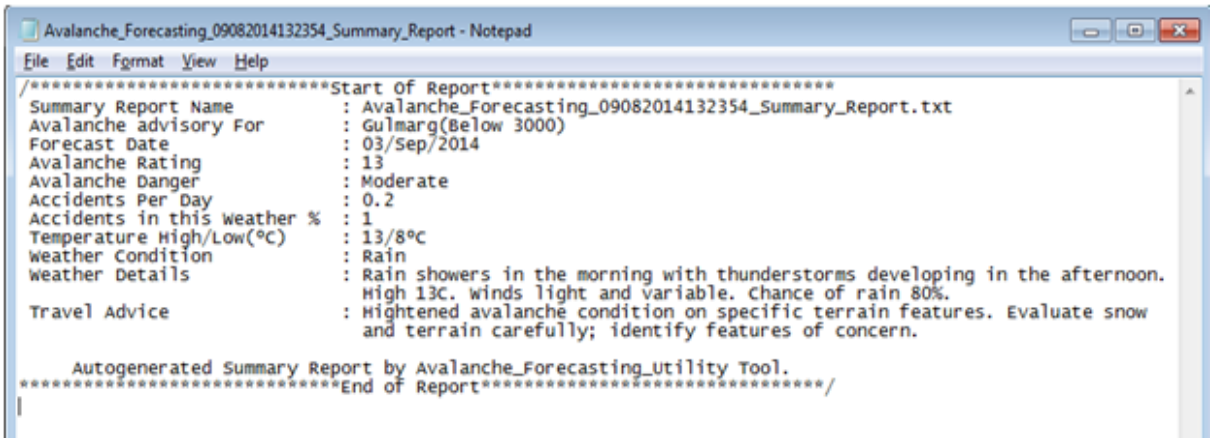

Fig. 1.7: Screen Shot of Auto generated Report

G. Click On "Show/Hide" Button To Check The Analysis Data:

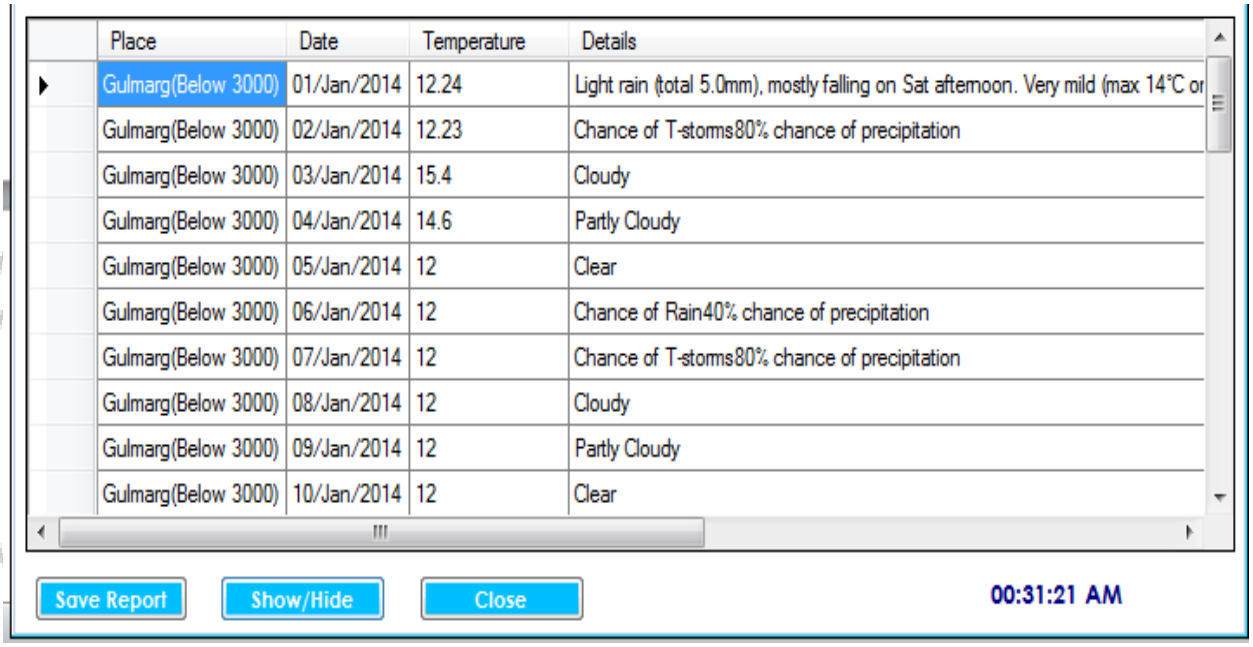

Fig. 1.8: Screen Shot of Data Analysis

XIII. SOFTWARE SPECIFICATION

Avalanche Forecasting Utility	
Description	Avalanche Forecasting Utility light weight windows application for forecasting of different avalanche zones, show travel advices, avalanche advisory and weather details.
Platform	Microsoft Visual Studio C#/.Net Framework
Data source	Excel sheet (Avalanche.xlsx)
Programming Language	C#/.Net

Avalanche forecasting utility software is a windows application which is designed with the help of Microsoft Visual Studio, C sharp.net and Excel complete detail is given below in the table:

The developed model completely based on previous available avalanche related data which were helpful to initialized particularly weather and desired location wise avalanche forecasting utility software this software work like a forecasting tool and designed as a statistical analysis model.

XIV. RESULT

To be effective, any kind of avalanche control must be carried out on a consistent basis during periods of instability throughout the entire winter season.

The developed model of avalanche forecasting is can be used as a working model for predicting and avoiding to interact with avalanche threat.

The reoccurrence of avalanches at the same topographic site or sites means that mapping offers a route to hazard mitigation, if only through the qualitative recognition, and avoidance, of susceptible sites.

XV. CONCLUSION

There are various ways of mitigating the hazards of avalanches. One is to trigger smaller avalanche artificially at chosen times under controlled conditions before the snow masses grow big enough to cause natural unpredictable avalanches. The artificial triggering is done by hurling explosive projectiles through guns. The other way is to deflect or divert the moving mass by building wind baffles, snow fences, snow nets, breaking barriers, etc. So that the snow masses do not accumulate to dangerous proportions. Retaining walls, fences and avalanche wedges can ward hazards to building and installations. Extraordinary avalanche events result from unusual snowpack's, unusual storm events, or both. Avalanche activity was notable throughout the region, and resulted in considerable damage to buildings and forests, disruption of recreational facilities and transportation corridors, and several fatalities. Accurate prediction of an avalanche, both in terms of its likelihood as well of the likely period of occurrence, remains an extremely difficult task. In the environment of automated real-time data collection, high quantum of information may be available for rigorous analysis on a real-time basis. Such real-time analysis and selection of one outcome from among the multitudes of possibilities, is likely to be possible only through the assistance by some sort of automated prediction system.

XVI. FUTURE ADVANCEMENT

Can be connected to database for real-time weather details for any specific terrain across the globe.

Time based weather details can also be added to forecast the advisory for specific time with real-time weather details.

Conventional avalanche parameter such as Stability factors, existence of weak layers, crystal forms and sizes, densities and metrological character can also be added.

Snowpack information as time lines, snow cones, snow roses, snow profiles, etc. can also be added for more precise forecasting.

Option to send summary report via email can also be added to share the avalanche advisory to any person across the globe. It would further help to spread awareness in less time.

Can be customized further to generate and send the advisory for specific terrain automatically for each day.

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