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Recent tectonics and seismic microzonation of Dehradun city, India

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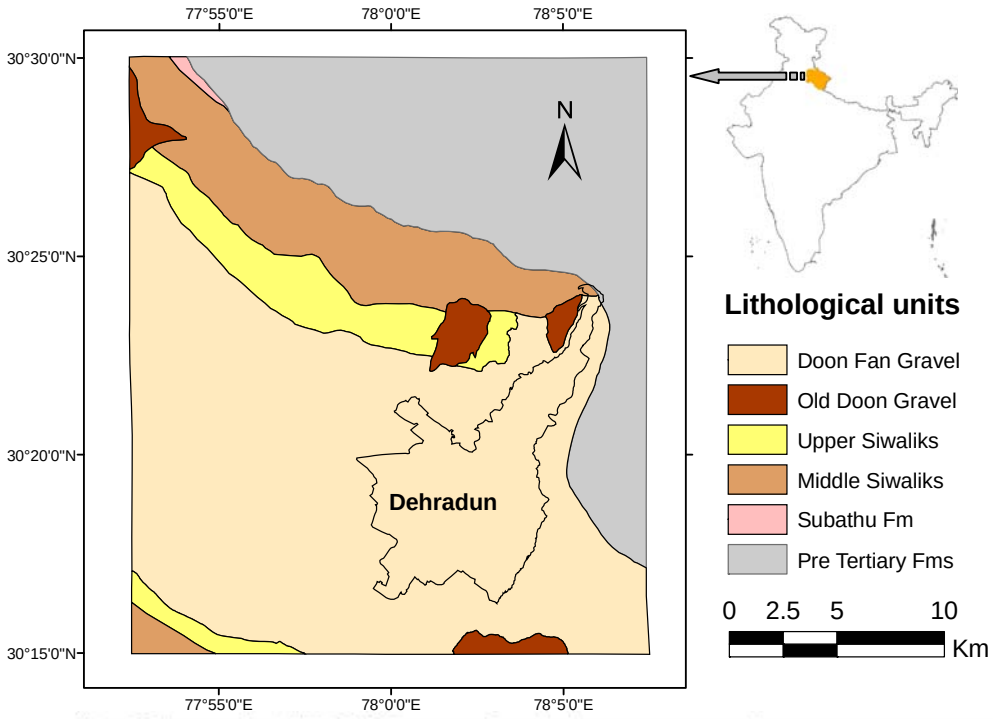
Abstract

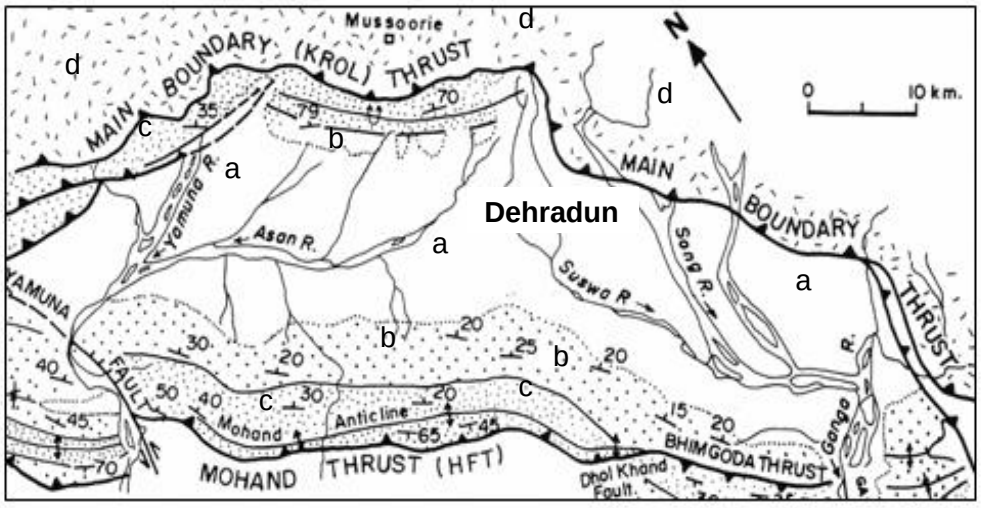
Dehradun city, situated in Doon valley, bounded by two important faults i.e. Main Boundary Fault and Himalayan Frontal Thrust is one of the most seismically active zones of India. In the recent past it was affected by all major earthquakes of the region i.e. 1905 Kangra, 1991 Uttarkashi, and 1999 Chamoli. Recently the city has gained further prominence as it was declared as the interim capital of the newly formed state of Uttaranchal resulting in increase in population and seismic risk. Realising this, IIRS in collaboration with Wadia Institute of Himalayan Geology and ITC, the Netherlands had initiated a study on development of a methodology for seismic hazard assessment and microzonation for Dehradun city.

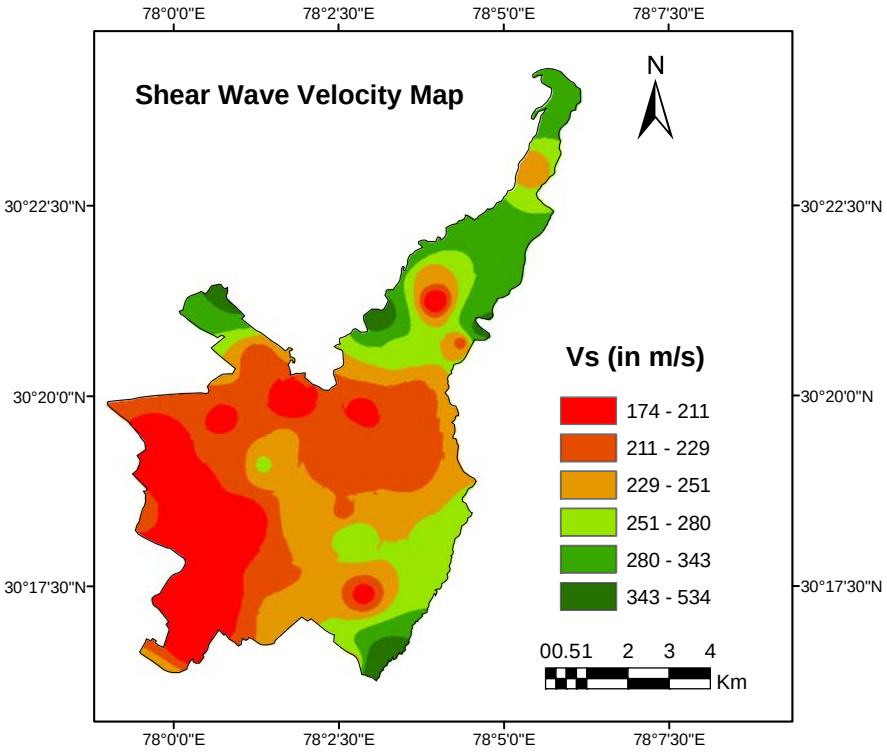
Geology and geomorphology of the area was characterised in terms of rock types and geomorphological units. Seismo-tectonic lineaments have been identified and tectonic activity along major structural features have been studied using temporal data sets of Landsat MSS and IRS LISS-III and PAN (30 years interval). In the northern part of the Doon valley various faults in concordance with the MBT show evidences of deformation marked by landslides and displacement of fan deposits of mostly Holocene period. With the available data sets, in the northern part, evidences of recent tectonics in last 30 years could not be confirmed. However, in the southern part beyond HFT, the on going deformation has resulted in characteristic geomorphic expression such as shifting of drainages towards eastern side, development of new streams, shifting of stream confluence towards north, and close meanders. Shifting of streams flowing southward from Mohand anticline has resulted in widening of drainage course over last 80 years. Based on such observation, it could be concluded that compared to MBT, the HFT region is more active in the recent times, thereby suggesting higher seismic hazard in the surrounding region.

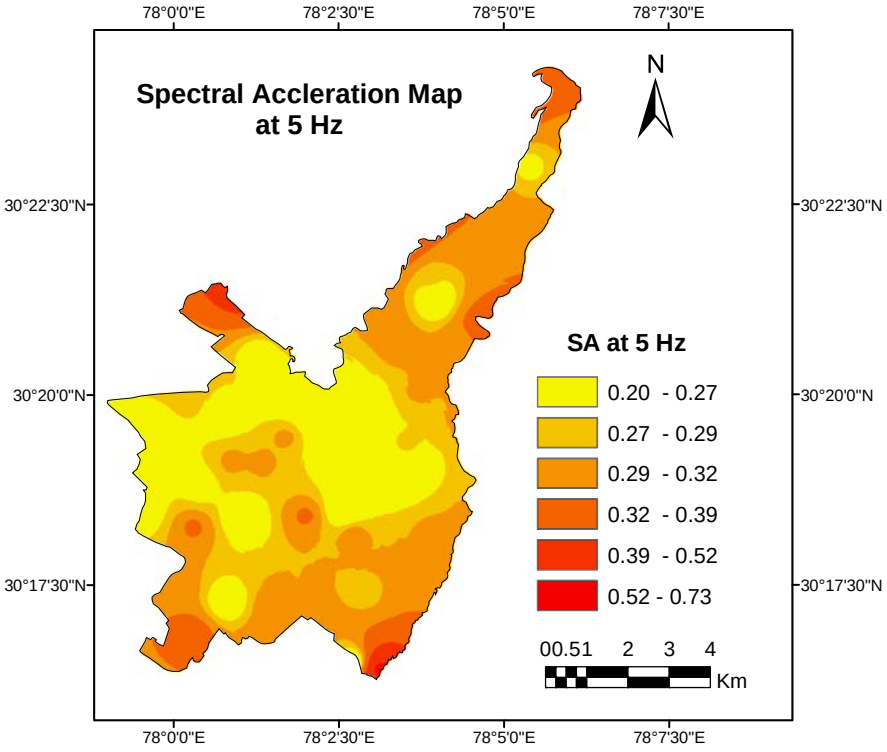
It is a well known fact that in an earthquake, the damage at a site is greatly influenced by the response of the local geology and soil column. In seismic response analysis, the site response is calculated in the form of response spectra for a particular site. Various parameters that are needed for seismic response analysis are soil profile and its thickness, depth to bedrock, geotechnical properties of the soil, shear wave velocity and input earthquake data. In the present study, shear wave velocity and soil thickness was obtained by using one of the most recent techniques i.e., Multi channel Analysis of

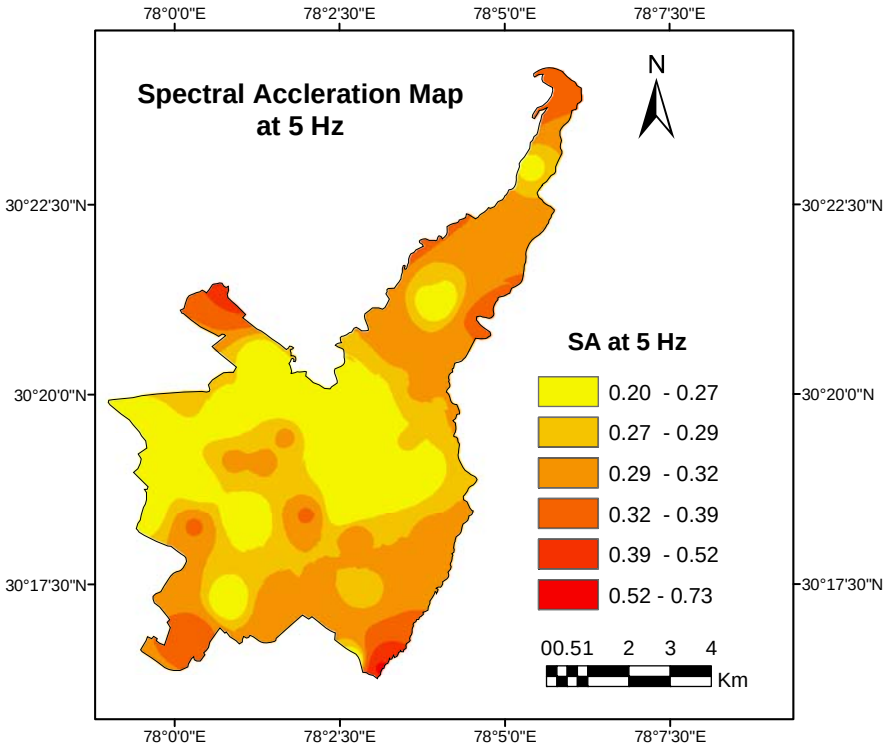
Surface Waves (MASW) method. By using this technique, 31 sites have been covered in the study area to know the shear wave velocity variation and the material depth in the city for upper 30 m, which is considered as ideal for seismic response analysis world over. The calculated shear wave velocity of different sites is compared with tube well lithologs and local geology to know the different material types. SHAKE 2000 has been used for site response modelling using Chamoli and Uttarkashi earthquake data recorded at Tehri as input motion. On the basis of present analysis whole city has been classified in to different zones of shear wave velocity and spectral acceleration. The study shows shear wave velocity varying from 200m/s to 700 m/s in upper 30 m of the sub-surface profile. The maximum spectral acceleration was observed at 2-3 Hz frequency indicating vulnerability of 3-5 storied buildings. At 3 Hz frequency, high spectral acceleration in the south western part of the city indicates the role of thick layers of soft sediments, which will also cause higher amplification of shear wave velocity. Although the study shows encouraging results, in a spatial domain using a geo-database, it has limitations. Due to limited bore hole data and wide variability in the fan deposits of the Doon valley, shear wave velocity/ spectral acceleration may vary locally. Secondly, the reference motion data is taken from Tehri, which is on a different topography than Doon valley. The characteristic basin topography and its resultant effect on attenuation of seismic waves can be incorporated by taking reference motion from Doon valley; unfortunately such data was not available for the present study.

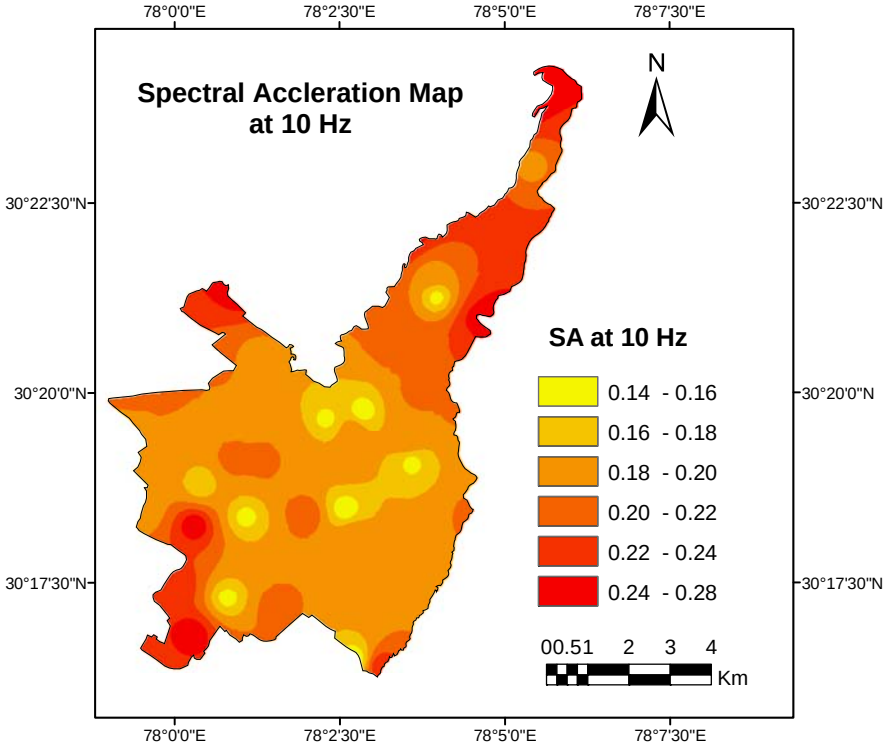

77°55'0"E
78°0'0"E
78°5'0"E
30°30'0"N
30°25'0"N
30°20'0"N
30°15'0"N
N
Dehradun
Lithological units
Doon Fan Gravel
Old Doon Gravel
Upper Siwaliks
Middle Siwaliks
Subathu Fm
Pre Tertiary Fms
0 2.5 5 10
Km


Mussoorie
MAIN BOUNDARY (KROL) THRUST
MAIN BOUNDARY THRUST
Dehradun
Yamuna R.
Asan R.
Suswa R.
Song R.
Ganga R.
YAMUNA FAULT
Mohand Anticline
MOHAND THRUST (HFT)
BHIMGODA THRUST
Dhol Khand Fault
0 10 km.
a
b
c
d


Shear Wave Velocity Map
N
Vs (in m/s)
174 - 211
211 - 229
229 - 251
251 - 280
280 - 343
343 - 534
00.51 2 3 4
Km
78°0'0"E
78°2'30"E
78°5'0"E
78°7'30"E
30°22'30"N
30°20'0"N
30°17'30"N


Spectral Accleration Map at 5 Hz
N
SA at 5 Hz
0.20 - 0.27
0.27 - 0.29
0.29 - 0.32
0.32 - 0.39
0.39 - 0.52
0.52 - 0.73
00.51 2 3 4
Km
78°0'0"E
78°2'30"E
78°5'0"E
78°7'30"E
30°22'30"N
30°20'0"N
30°17'30"N


78°0'0"E
78°2'30"E
78°5'0"E
78°7'30"E
Spectral Accleration Map at 5 Hz
N
30°22'30"N
30°20'0"N
30°17'30"N
SA at 5 Hz
0.20 - 0.27
0.27 - 0.29
0.29 - 0.32
0.32 - 0.39
0.39 - 0.52
0.52 - 0.73
00.51 2 3 4
Km


78°0'0"E
78°2'30"E
78°5'0"E
78°7'30"E
Spectral Accleration Map at 10 Hz
N
30°22'30"N
30°20'0"N
30°17'30"N
SA at 10 Hz
0.14 - 0.16
0.16 - 0.18
0.18 - 0.20
0.20 - 0.22
0.22 - 0.24
0.24 - 0.28
00.51 2 3 4
Km