District Wise Soil Fertility Mapping from Soil Health Card Data Using GIS in Meghalaya

Pratibha Thakuria Das[1*], Bipul Saikia[2], Tangwa Lakiang[2], R. M. Majaw[3], Ian B. Saiborne[4]

*1*Scientist/Engineer-SF, Department of Space, North Eastern Space Applications Centre, Govt. of India, Umiam, Meghalaya, India*
Email: thakuriapratibha@rediffmail.com
2 Project Support Services Department of Space, North Eastern Space Applications Centre, Govt. of India, Umiam, Meghalaya, India
Email: saikiabipul22@gmail.com, tangie18lakz@gmail.com
3Joint Director of Agriculture, Govt. of Meghalaya, Shillong
Email: royaltymajaw@gmail.com
4Assistant Director of Agricultutre, Govt. of Meghalaya, Shillong
Email: ianbsaiborne@gmail.com

--******************************--

Abstract:

Soil fertility maps, namely soil acidity, salinity, organic carbon, available phosphorus, and potassium were generated using Geographic Information System from grid-wise soil health data collected from SHC Portal. The study revealed that soils of all districts of Meghalaya are non-saline. The soils of all districts of the State (except two districts of Jaintia hills) are mostly slightly acidic with the highest area in West Garo Hills and South West Garo Hills that cover the entire districts whereas the moderately acidic soils are more abundant in East Jaintia Hills and West Jaintia Hills districts that cover 97.06% and 85.56% area respectively. The strongly acidic and neutral soils are found in very negligible areas. All districts of Jaintia Hills and Khasi hills are rich in organic carbon covering 99% area. More than 54% of areas of the districts of Meghalaya have medium available phosphorus and the highest area is found in North Garo hills (91%). Available phosphorus is high in 35% of soils of East Khasi hills followed by South West Khasi Hills (19.89%) and West Khasi Hills (16.12%) district. Availability of potassium is low in >66% areas of 6 districts (South West Khasi Hills and all five districts of Garo hills) whereas > 52% areas of 5 district of Jaintia Hills and Khasi hills (except South West Khasi hills) are medium in available potassium. Soils of Ri-bhoi, East Jaintia Hills, West Khasi Hills, and East Khasi Hills districts contain high available potassium covering 19.91%, 17.76%, 10.97%, and 7.54% area, respectively.

Key Words: **Soil fertility, Soil Health Card, GIS, Meghalaya**

--******************************--

I.   Introduction

Effective soil fertility management is possible through site-specific nutrient management that considers spatial variations in nutrient status and reduces the possibility of over or underuse of fertilizer. Based on location-specific variability in nutrient availability in soil, optimum doses of fertilizers/ nutrients can be applied to soil as per the crop nutrient demand [1].There are several techniques for soil fertility evaluation. Amongst all, soil testing is the most popular as well as more appropriate method and it provides information regarding the number of nutrients available in soils based on which optimum doses of fertilizer are recommended for economic production of different crops [2].Thus sustainable soil management is possible through soil analysis [3].Soil properties vary spatially from a small to a larger area might be due to the effect of intrinsic (climate, parent materials, and physiography) and extrinsic factors such as indigenous fertility status, nature of standing crop, cropping intensity, crop rotation, and soil management practices [4]. Describing the spatial variability of soil fertility

across a field has been difficult until new technologies such as Global Positioning Systems (GPS) and Geographic Information Systems (GIS) were introduced. The collection of soil samples by using GPS is very important for preparing thematic soil fertility maps [5]. Similarly, Geographical Information System (GIS) is a powerful tool used for easy access, retrieval, and manipulation of voluminous data and deriving spatial maps based on soil sample analysis data collected from different locations [6]. GIS provides the platform for the conversion of location-specific (point) information to spatial maps for the entire block/district/state. It facilitates the manipulation of spatial and non-spatial data useful for handling multiple data from the diverse origin [7]. Based on the geostatistical analysis, several studies have been conducted to characterize the spatial variability of different soil properties [5, 7, 8, 9, 10, 11, & 12]. Furthermore, GIS-generated soil fertility maps may serve as a decision support tool for sustainable nutrient management [14].

Soil Health Card (SHC) scheme is a Government of India's scheme under the *National Mission for Sustainable Agriculture (NMSA).* The SHC gives the information about soil nutrient status of crop fields and advice on optimum dosages of fertilizers for different crops along with needed soil amendments to maintain soil health in the long run. Soil Health Cards are prepared based on soil test results for which grid-wise surface soil samples are collected along with the location (latitude, longitude) information recorded by using GPS. Even though soil samples are geo-coded but SHC does not contain maps showing spatial variation in nutrient status of the crop field. Directorate of Agriculture, Govt. of Meghalaya has collected geo-coded soil samples from the entire state for SHC preparation. But the department does not have a spatial map of soil fertility status. Therefore, based on the request from the department, an attempt has been made to prepare a district-wise soil fertility map of Meghalaya from SHC data by using GIS.

II. Materials and methods

Soil analysis results and soil sample location information has been collected from the SHC dashboard for the generation of soil fertility map. The downloaded data has been edited in Microsoft Excel and the non-spatial data has been brought to GIS compatible format. The non-spatial data has been converted to spatial data as a point layer by entering latitude, longitude information of 49000 soil samples by using ArcGIS 10.3 software. The point layer contains soil sample numbers, village name, and soil sample analysis results of pH (soil acidity), EC (soil salinity), OC (organic carbon), available P (Phosphorus), and K (potassium). The point layer has been interpolated and spatial maps have been generated for five parameters i.e. pH, EC, OC (Physical parameters), and P, K (Macro-nutrients). Inverse Distance Weighted (IDW)

interpolation technique available in the Spatial Analyst tools of Arc Toolbox was used for the generation of spatial maps showing soil nutrient variability at different places. The district and block boundary map has been overlaid with the state fertility map and a district-wise fertility map has been prepared. The methodology is described in detail in Figure 1.

III. Results and Discussion

Five fertility maps namely soil acidity, soil salinity; organic carbon, available phosphorus, and potassium were generated for all the districts of Meghalaya. From the study, it has been observed that the soils of all districts of the State (except two districts of Jaintia hills) are slightly acidic with the highest area in West Garo Hills and South West Garo Hills that cover the entire districts followed by North Garo Hills, East Garo Hills and South Garo hills. The moderately acidic soils are more abundant in East Jaintia Hills and West Jaintia Hills districts that cover 97.06% and 85.56% area respectively followed by East Khasi Hills (33.62%) district. The strongly acidic and neutral soils are found in very negligible areas (Fig. 2a & Fig. 4). Soils of East Khasi hills are rich in organic carbon covering 99.72% area followed by West Jaintia Hills (99.51%), East Jaintia Hills (99.39%), Ri-bhoi (99.06%) districts. Medium organic carbon is found the highest in soils of South West Garo Hills district that covers 49.28% area followed by West Garo hills (33.54%), North Garo Hills (31.60%), and the other districts of Garo Hills (Fig. 2b & Figure 4). The soils of all districts of the state are found to be medium in available phos-
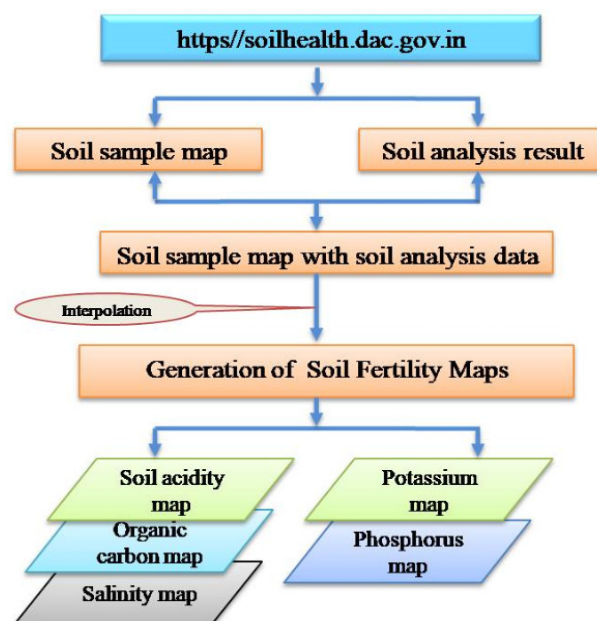

Fig. 1 Flow chart of the methodology for soil fertility mapping.

phorus and the highest area is found in the North Garo Hills district that covers 91.30% area followed by South West Garo hills (84.96%), East Garo hills (81.97%) district. The availability of phosphorus is high in soils of East Khasi hills that cover 35.83% area which is the highest in the state followed by South West Khasi Hills (19.89%) and West Khasi Hills (16.12%) district. Low available phosphorus is found in soils of all districts that cover less than 26% area and the highest area is found in the West Garo Hills district (Fig. 3a & Fig. 5). The soils of all districts of Meghalaya contain low available

potassium covering the highest area in West Garo Hills district (86.21%) followed by South Garo Hills (78.18%) and North Garo Hills (78.17%) district. The soils of West Jaintia hills are medium in available potassium covering the highest area (73.27%) followed by Ri-bhoi (66.49%) and West Khasi Hills (64.07%) district. High available potassium is found in soils of Ri-bhoi district covering 19.91% area which is highest among all districts followed by East Jaintia hills (17.76%) and the other districts of Khasi and Jaintia hills (Fig. 3b & Fig. 5).
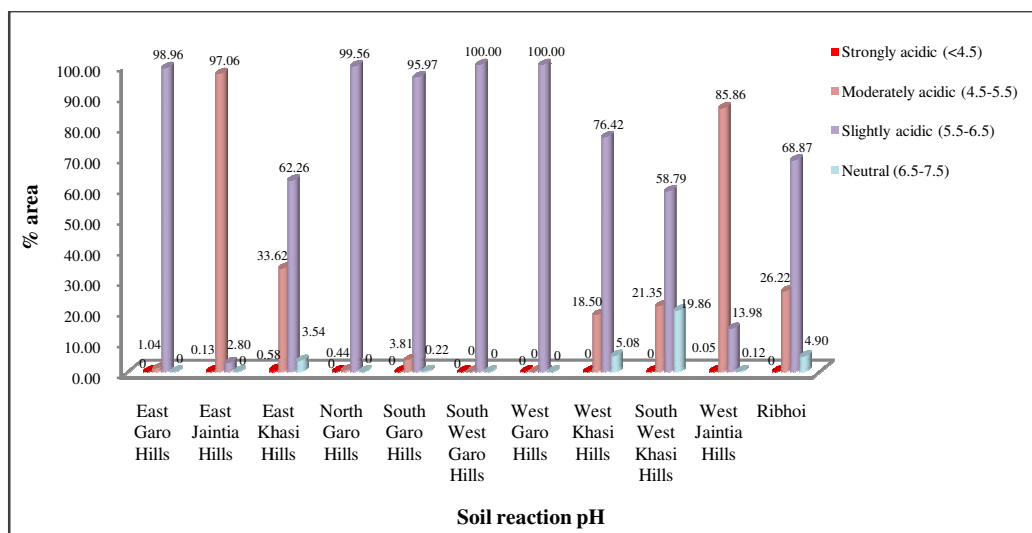

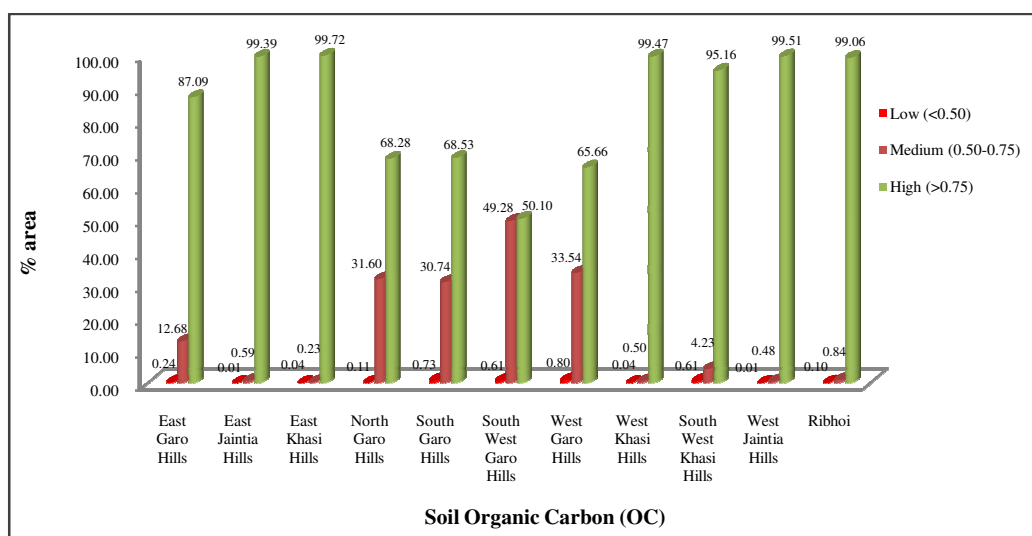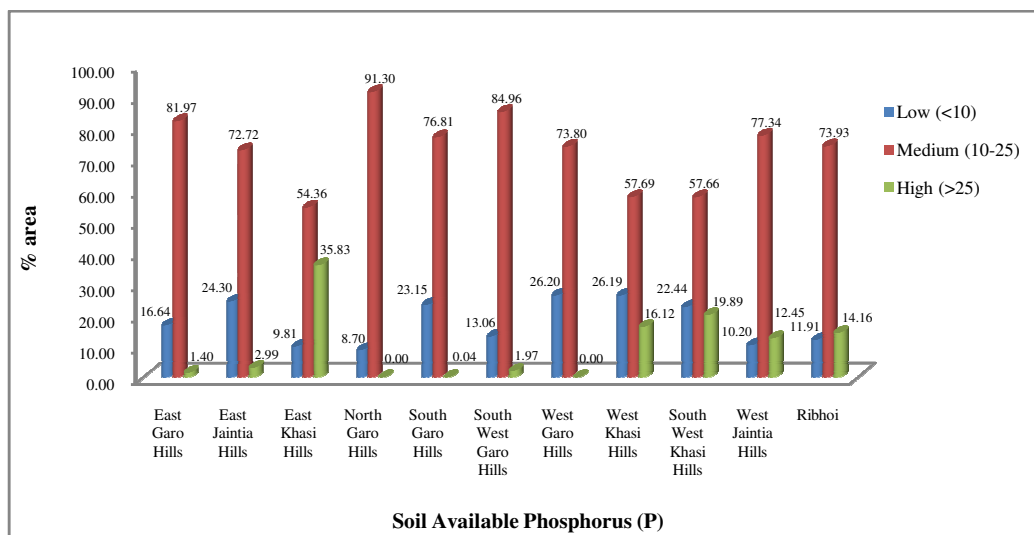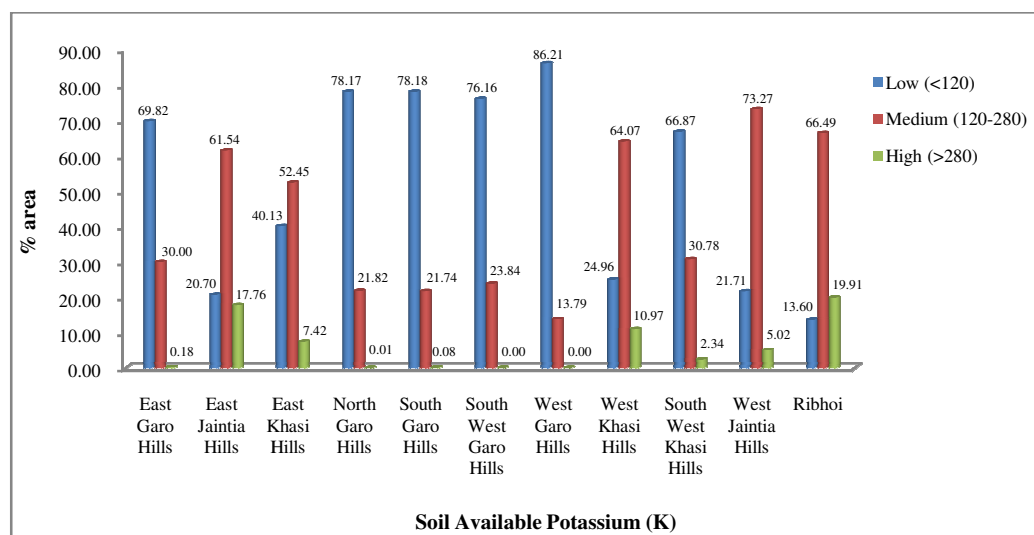**Fig. 2a** District-wise distribution of Soil Acidity (pH) Classes

Fig. 2b District-wise distribution of Organic Carbon (OC) Classes

Fig. 3a District-wise distribution of Available Phosphorus Classes

Fig. 3b District-wise distribution of Available Potassium (K) Classes
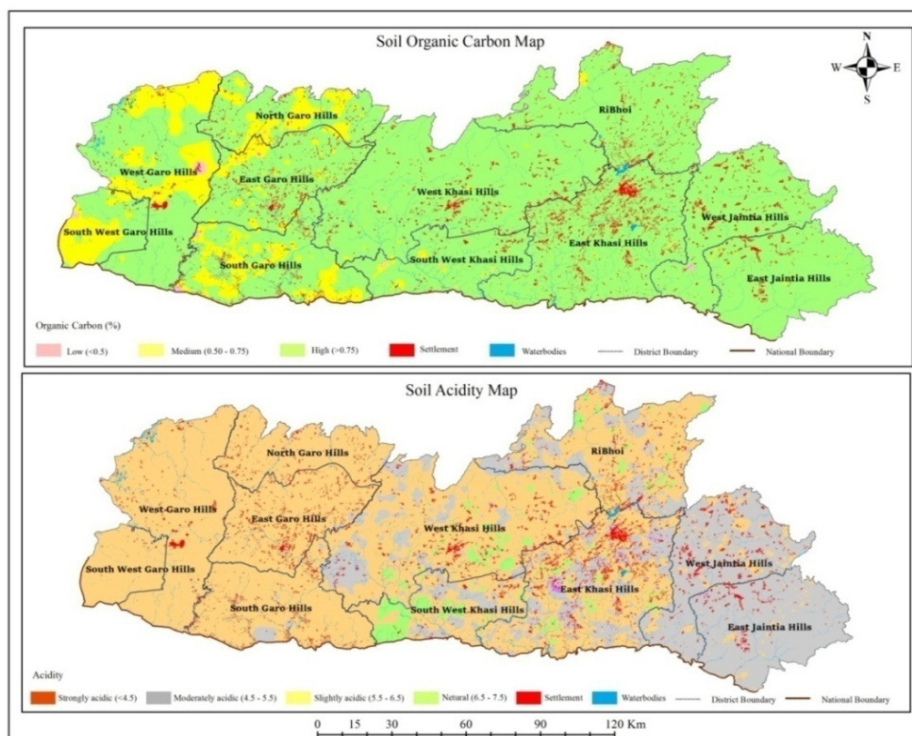
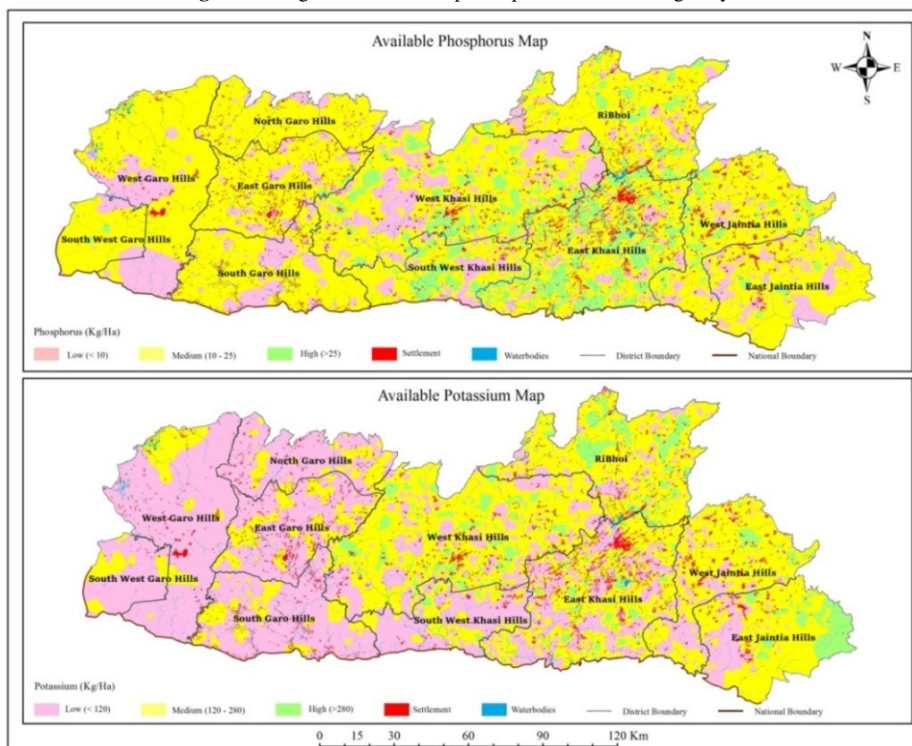**Fig. 4** Soil Organic Carbon and pH map in districts of Meghalaya.

Fig. 5 Soil Available Phosphorus and Potassium map in districts of Meghalaya.

IV.   Conclusions

The study gives an example of utilization of Soil Health Card data in the form of soil analysis results and location of soil samples for generation of spatial maps in simpler visual interpretations which are useful for recommending a proper dose of soil fertilizers and other nutrient management practices to increase crop production without soil degradation and helps in sustainable agriculture. The study revealed that soils of all districts of Meghalaya are non-saline, acidic, and contain high organic carbon. The availability of phosphorus and potassium varies from high to low.

Acknowledgements

References

[1]   A. Dobermann, K. G. Cassman, "*Plant nutrient management for enhanced productivity in intensive grain production systems of the United States and Asia 2002.*"

[2]   D. Khadka, S. Lamichhane, R. Amgain, S. Joshi, S. P. Vista, K. Sah, N. H. Ghimire, "Soil fertility assessment and mapping spatial distribution of Agricultural Research Station, Bijayanagar, Jumla, Nepal." *Eurasian J Soil Sci*, 8(3):237–248, 2019.

[3]   S. C. Panda. "Soil Management and Organic Farming. Agrobios, Bharat. *Printing Press Jodhpur,* India 462, 2010

[4]   C.A. Cambardella, D.L. Karlen. "Spatial analysis of soil fertility parameters." *Precision Agriculture*, 1(1): 5-14, 1999

[5]   S. Bandyopadhyay, P. Ray, S. Padua, S. Ramachandran, R. K. Jena, P D. Roy, S. K. Ray, "Priority Zoning of Available Micronutrients in the soils of Agro-ecological Sub-regions of North-East India Using Geo-spatial Techniques." *Agricultural Research*, 7(2): 200-214. 2018

[6]   A. K. Mandal, R. C. Sharma, "Computerized database of salt-affected soils for Peninsular India using GIS." *Geocarto International* 24; (1):64-85. 2009

[7]   A. Alam, N. Subhan, H. Hossain, M. Hossain, H. M. Reza, M. Rahmana, M. O. Ullah. "Hydroxycinnamic acid derivatives: a potential class of natural compounds for the management of lipid metabolism and obesity." *Alam et al. Nutrition & Metabolism* 2016.

[8]   G. Singh, B. Kumar, Shashikant. "Soil Fertility Mapping Using Remote Sensing and GIS in NSP Farms of ND University of

Agriculture and Technology. Kumarganj, Faizabad, Uttar Pradesh, India. *Int J Curr Microbiol App Sci* 7:1394-1402. 2018

[9]   M. A. Ravikumar, P. L. Patil, G.S Dasog. "Characterization and mapping of soil resources of 48A distributaries of Malaprabha right bank command, Karnataka for land use planning." *Karnataka Journal of Agricultural Sciences* 22:81-88, 2004

[10] B. Huang, W. Sun, Y. Zhao, J. Zhu, R. Yang, Z. Zou, F. Ding, J. Su. "Temporal and spatial variability of soil organic matter and total nitrogen in an agricultural ecosystem as affected by farming practices." *Geoderma*, 139(3-4):336345, 2007

[11] D.C. Weindorf, Y. Zhu, "Spatial variability of soil properties at Capulin volcano, New Mexico, USA: Implications for sampling strategy." *Pedosphere*; 20(2):185-197, 2010

[12] K. Prabhavati, G .S. Dasog, P. L. Patil, K. L. Sahrawat, S. P. Wani1, "Soil Fertility Mapping using GIS in Three Agroclimatic Zones of Belgaum District, Karnataka," *Journal of the Indian Society of Soil Science*; 63(2):173-180, 2015

[13] W. Iftiker, G. N. Chattopadhayaya, K. Majumdar, G. D. Sulewski, "Use of village-level soil fertility maps as a fertilizer decision support tool in the red and lateritic soil zone of India Better crops," 94:10-12, 2010