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Water resources planning for the micro watersheds using geospatial techniques

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Abstract
Geospatial techniques were used for land and water management action plan for some part of Purna-Tapi micro watershed in Akola district, Maharashtra. Keeping in view the need of micro level planning and usefulness of modern tools and technology a study on Water resource planning of water resources for micro watershed was conducted. The objectives of the present research work was to prepare the thematic maps of land use/ land cover, soil, slope and drainage using satellite imagery data and survey of India (SOI) toposheet of micro watershed and to integrate all the maps under GIS environment to prepare the water resource management plans for the study of micro watershed. The study will be helpful in identification of sites for construction of different soil and water conservation structures like water harvesting structures, check dams, farm ponds, percolation tanks, nala bunds, nala widening and deepening of drainage network etc. Different soil and water conservation works are suggested under water resource action plan with specific sites, locations and maps. The study will be helpful in sustainable development of the natural resources of the micro watershed with the proper implementation of the proposed action plans.

Keywords: GIS, remote sensing, land use, land cover maps, water resource management

Introduction
Water resource management planning has regard to all the competing demands for water and seeks to allocate water on an equitable basis to satisfy all uses and demands. Agriculture is the mainstay of the state of Maharashtra. Maharashtra's economy is predominantly agriculture based. It is the main occupation of the people. Both food crops and cash crops are grown in the state. The total irrigated area which has been used for crop cultivation is 33,500 square kilometres. The agriculture in the state is predominantly rain-fed. Agriculture is the largest user of the world's freshwater resources, consuming 70 percent. Geospatial technologies such as remote sensing (RS) and Geographic Information System (GIS) have been found to be effective tools for delineating rainwater harvesting potential zones and selecting sites for rainwater harvesting structures, and play a vital role in the planning and management of water resources (Jha & Peiffer 2006) [3]. The aim has been to ensure the availability of drinking water, fuel wood, and fodder and raise income and employment for farmers and landless labourers through improvement in agricultural production and productivity (Rao, 2000) [6].
For the region like Vidarbha in Maharashtra State of India, where precipitation is very uncertain and nearly 89% of the cultivated area is under rainfed farming there is required for water resources planning and development in the micro-watershed area. Thus on the same background, the study has been undertaken for micro watershed planning in the vicinity of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Agricultural University) for better utilization of rainwater and their water resources.

Study Area
The selected micro watersheds are in the campus area of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Krishi Nagar, Akola of Taluka and District Akola in Vidarbha region of Maharashtra. The study area is situated between 20°41' to 20°43' N latitude and 77° 02' to 77° 05' E longitude and at an altitude of 287 to 312 m above M.S.L. and is having an average annual rainfall of 779.12 mm. The micro watershed is situated in the purna-tapi watershed of Akola district. The micro watershed comes under the 3rd agro-climatic zone. i.e., Western Vidarbha Zone. The micro watersheds have 814 ha area which comes under Central Research Station, Dr. PDKV, Akola.

Materials and Methods

The different thematic maps were prepared using Arc GIS software 10.3. The location map of the study area is depicted in Fig. 1. The micro watershed boundary was delineated from digital elevation model with the reference of SOI topographical sheet, field survey using GPS instrument. The land use/land cover map of the micro watershed was prepared through visual interpretation technique from FCC data to study the land use pattern. Fig. 2 shows the land use and land cover map of the micro watersheds. The slope map and soil map was prepared by using toposheet. Different slope categories were delineated in Fig. 3. Satellite imageries and SOI toposheet were also used to prepare the drainage map of the micro watershed (Fig. 5). The information and current status for the hydrology and water resources (existing check dam, water harvesting structures (WHS), open wells, ponds etc.) in the micro watershed was also collected through manual survey, maps were prepared.

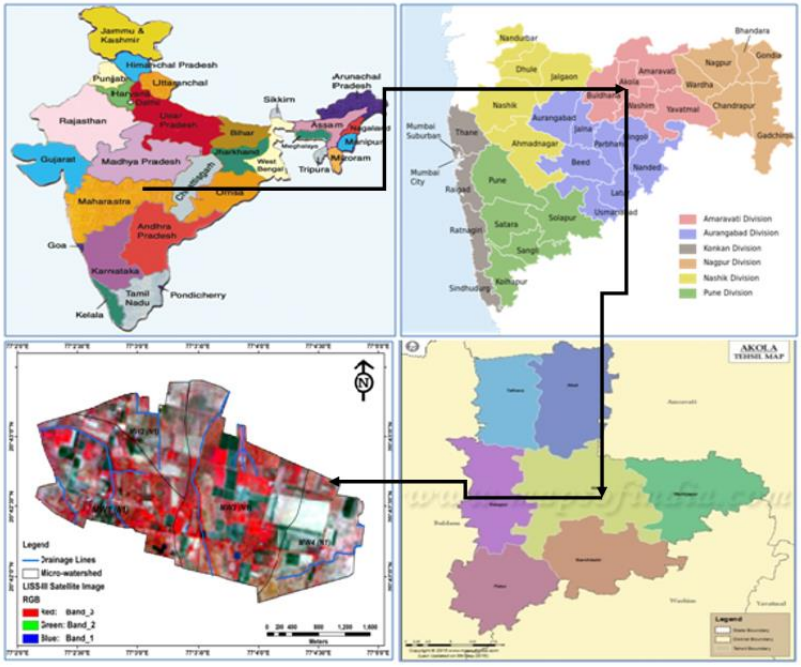

Fig 1: Location map of the study area

Results and Discussion

Land Use/Land Cover

Land use/ land cover map of Purna-tapi micro watershed was prepared through visual interpretation of satellite imageries and the spatial data in form of land use/land cover map with its different units were classified and presented (Fig.2). The results showed that there were Four land use classes in the micro watershed with a major part of the study area is conquered by Agricultural land (691.4 ha) which is 84.92% of the total area. This is followed by waste /fallow land (111 ha) which is 13.6%, built-up land (7.51 ha) which is 0.92 % of the total area and water bodies/ storage tank (4.24 ha) which is 0.52% of the total area.

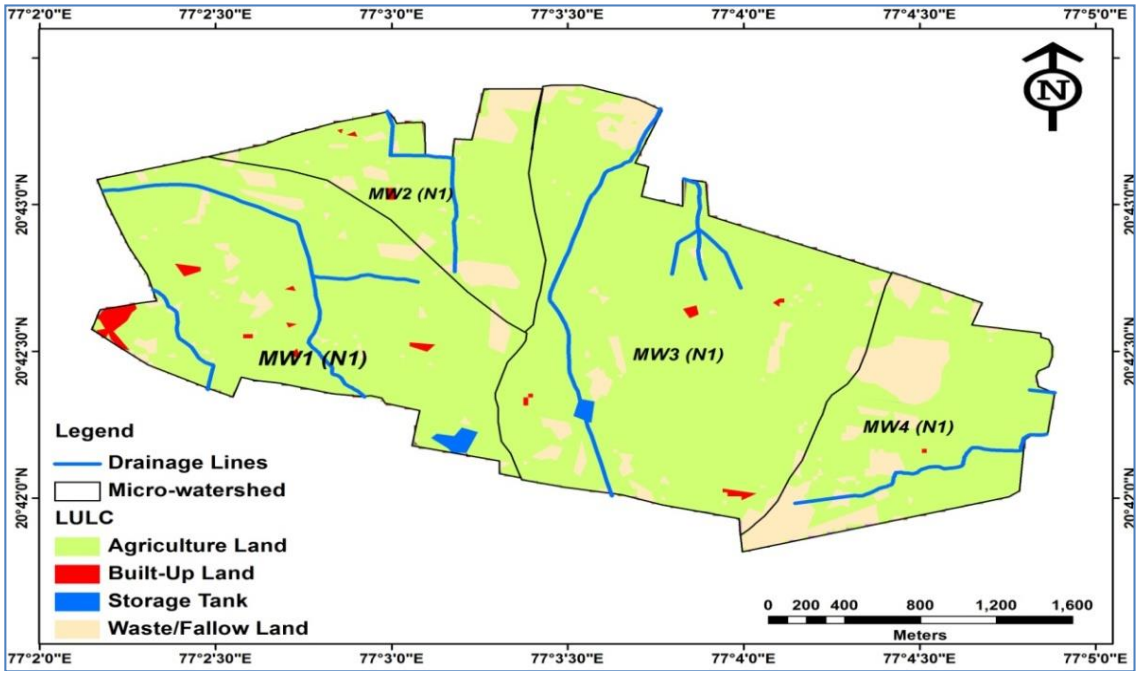

Fig 2: Land use land cover map

Slope map of the micro watersheds

The slope map of the micro watershed was prepared from satellite data using Arc GIS software 10.3 with the reference of Survey of India topographical map. The slope is the degree of inclination of the surface from horizontal expressed in percent or degrees. In a digital elevation model, the heights above MSL are shown by contours (lines of equal elevation), which also give an indication of the general topography and relief. The slope is one of the important terrain parameters, which can be explained by the horizontal spacing of the contours.

The slope can be calculated both in vector and raster forms. The slope is the change in gradient over a certain distance. The slope has been measured by taking a ratio of the difference in contour interval to the horizontal distance between contours. In general, closely spaced contours represent steeper slope and sparse contours exhibit gentle slope, whereas in the elevation output raster every cell has a slope value. Here, the lower slope values indicate the flatter terrain (gentle slope) and higher slope values correspond to the steeper slope of the terrain. The slope values can be measured in percentage. The Fig. 3 reveals that plain lands and very gentle slope (1-3%) area are mostly located on the central part of the study area and remaining is gentle slope (3-5%) area in the micro watersheds. The slope map (Fig. 3) was prepared using the contour information of survey of India topographical maps on 1:50000 scales with 10 meter contour interval. The slope map of the micro watersheds is depicted in fig. 3.

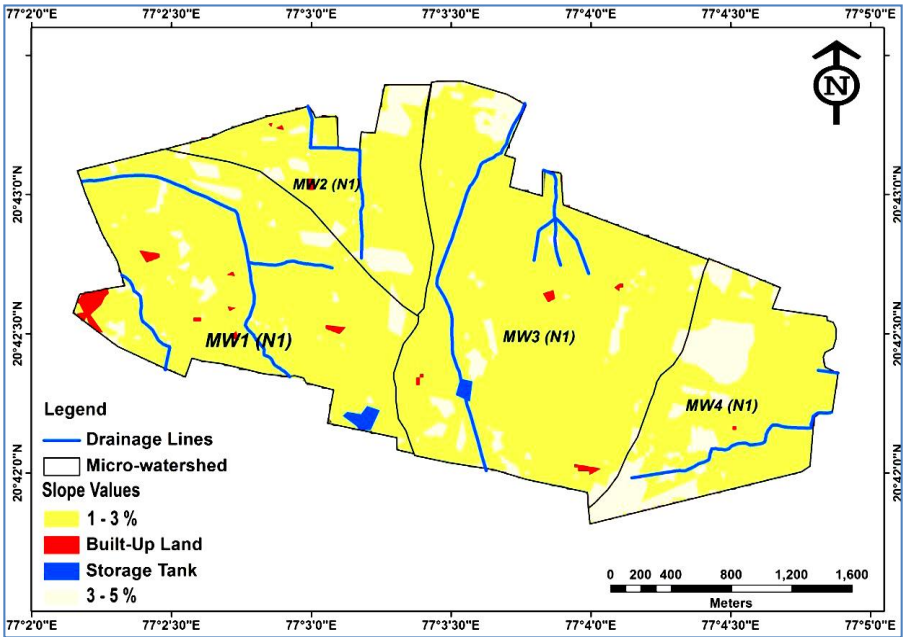

Fig 3: Slope map of the micro watersheds

Soil texture

The predominant textures of the soil profiles in the entire study of the micro watersheds were found of clayey which contribute maximum area 760 ha, which is 93.36 %, while gravel clay loam and built-up land contributes 5.52 % and 1.08 % respectively (Fig. 4). Soil erosion depends much on the infiltration rate of a soil. The infiltration rate is depending on the soil texture. In a clayey soil, it may be initially high (for heavy black clay with cracking) but becomes low when the soil is moist to wet. The soil map of the micro watersheds is depicted in fig. 4.

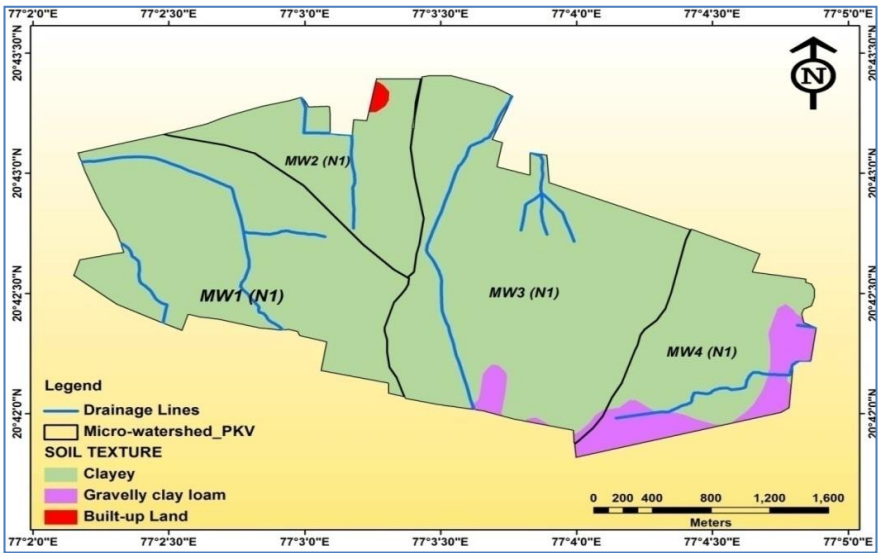

Fig 4: Soil Texture Map of the Micro Watersheds

Drainage of the micro watersheds

Drainage map was prepared by using Survey of India Topographic maps on 1:50,000. All the streams existing in this Micro watershed are marked and depicted in Fig 5. The entire area of the Micro watershed is drained by Nalas (N). The drainage pattern is typically dendritic and is controlled by the initial slope. Here the seasonal undefined means seasonal flow of water comes in those 1st order streams when it rains only. Water continuity shows the 2nd order streams in the micro watershed. After delineation of different thematic maps, they were superimposed in GIS environment to prepare the water and land resource management plans for the study micro watersheds.

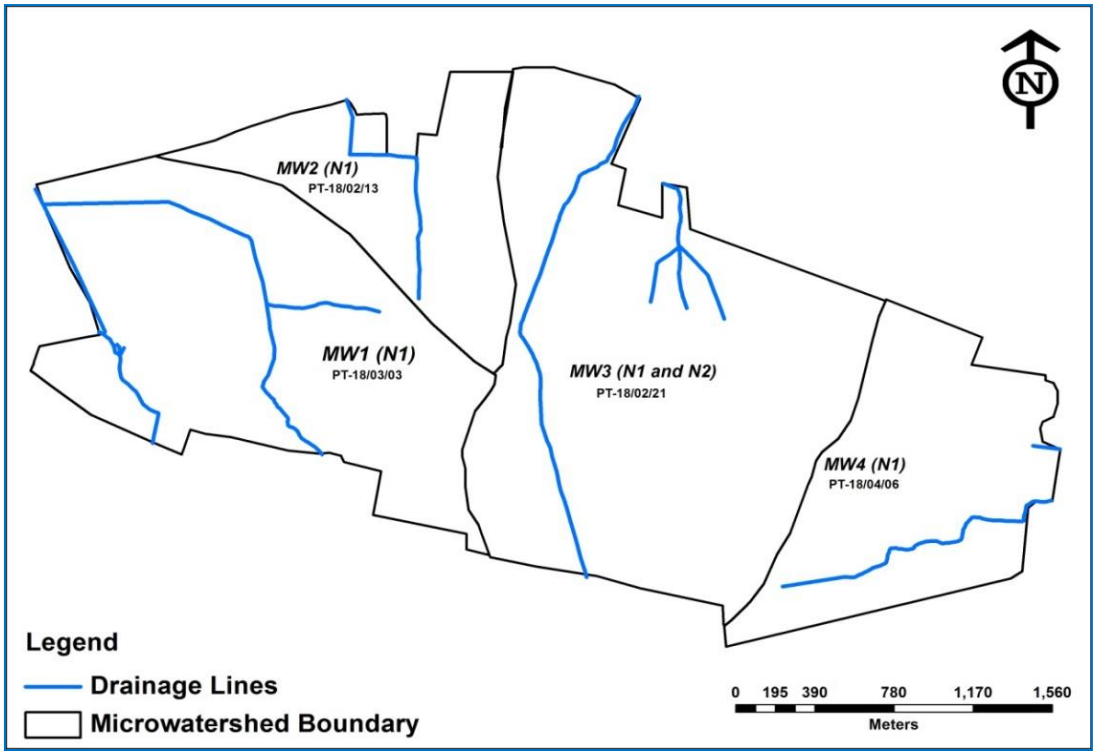

Fig 5: Drainage map of the Micro watersheds

Discussion

Water resources development plan

The water resource development plan of Purna-tapi micro watersheds was prepared by overlaying land use/land cover map, slope map, soil map and drainage map using Arc-GIS software packages in GIS, respectively. The water resources management plan is generated to make the judicious and effective use of water resources of the micro watershed to enhance the productivity and mitigate drought. The plan indicates sites for surface water development and groundwater exploitation. Different engineering structures are proposed for the water resource development and are depicted in Figs. 6. The planning for water resource reflects the approach for the use of the resources in a careful manner for sustainable development of the micro watershed. Action items have been suggested such as widening, deepening and reshaping of existing drainlines, Existing farm pond, CNB and open well should be reshaped, seven bore wells and four farm pond are proposed along the drain lines for maximum storage of surface runoff. As a result of widening and deepening work, reshaping of farm ponds, reshaping of storage in rainwater harvesting structures there will be certain benefits and outcomes in various forms and ultimately enhancement in groundwater recharge, availability of water for irrigating rabi crops, availability of water in surrounding wells, bore wells and storage structures, increase of area under irrigation can help in more production and it can generate employment opportunities, and overall revenue generation by creating other means.

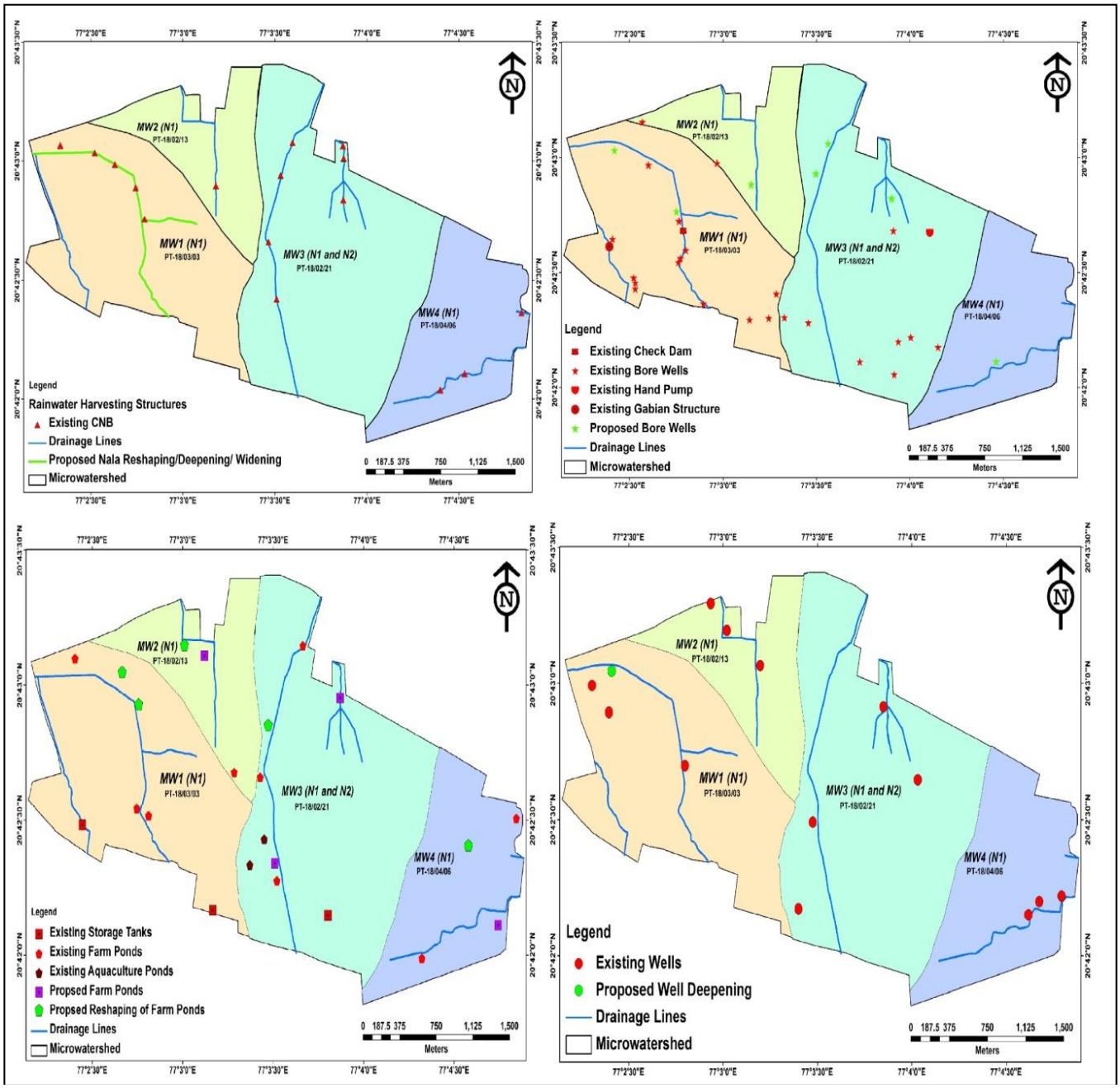

Fig 6: Proposed planning for micro watersheds

Conclusion

- Purna-Tapi micro watershed is one of the potential regions for agricultural development. Thematic maps including land use/land cover map, drainage, soil texture, DEM, and slope maps were generated using RS and GIS technique.
- The land use/land cover map was generated and it represents most of the area of micro watershed covered with agricultural land (691.4 ha) and later waste / fallow land (111 ha), built-up land (7.51 ha), and water bodies (4.24 ha) of the total area (814 ha).
- Identification of sites for construction of different soil and water conservation structures like bore wells and nala reshaping and widening of existing drainage lines etc, is possible due to this planning.
- Suitable soil and water conservation structures such as *in-situ* conservation structures, gully control structures and bore wells are proposed for water resource development of micro watershed according to their requirements and field conditions.

Acknowledgement

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