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Vegetation and erosion on the Tibetan Plateau

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Various types of vegetation and erosion occur in the Yalutsangpo (Brahmaputra) River basin on the Tibetan Plateau. Glacier erosion, gravity erosion (landslides and rock avalanches), water erosion (rill erosion, gully erosion and channel erosion), and Aeolian erosion occur in different parts of the basin at different elevations and closely related to different types of vegetation. Eight typical types of vegetation develop in the basin. An alpine vegetation develops on the mountains with altitude over 4,000 m, with a coverage over 90% but a vegetation thickness of only 1-3 cm. Dry valley vegetation develops in the Yalutsangpo valley and its tributaries in the reach upstream from the confluence of the Lhasa River. Dry valleys are river valleys with two unique features: 1) deeply incised valley on plateau; and 2) significantly higher temperatures and evaporation rates and lower precipitation than the surrounding area on the plateau. Dry valley vegetation, with coverage of only 10-20%, consists of only lichen, moss and herbs of suitable for strong sunshine. Rill and gully erosions occur in the dry valleys. Very intensive Aeolian erosion occurs in the dry valleys and surrounding mountains. Blown sand dunes develop in the valley and mountain slopes and forms small deserts. Very poor vegetation develops on the active sand dunes but high coverage of vegetation occurs at fixed or semi-fixed sand dunes. In the grand Yalutsangpo Canyon in the east part of the river basin subtropical vegetation with coverage of almost 100% and high vegetation thickness controls all forms of water erosion and Aeolian erosion. Nevertheless, very deep riverbed incision causes very intensive gravitational erosion, with main forms of rock avalanches and landslides. Sclerophyllous forest grows in glacial gullies and moraine fans. The vegetation thickness increases from 2 cm in mountains of elevation of 5200 m to 20 m in the Grand Canyon of elevation of less than 2000 m. The taxa richness or the number of species, and the vegetation coverage is extremely low in the dry valleys at elevation of 3000-3500 m, and increase with both increasing and decreasing elevation. The richness and coverage reach the highest for the subtropical vegetation in the grand canyon and for the thin alpine vegetation on the top mountain at 5,000 m. Landslides, avalanches and debris flows cause the highest rate of erosion, some years of 30,000-400,000 t/km2a, which are the most important drive of morphological process.

A vegetation-erosion model was developed to assess the extent of soil erosion and development trend of vegetation in the context of existing and contemplated vegetation-based soil erosion controls under different climatic, topographical and soil conditions. The model recognizes four vegetation-mediated soil erosion states: (i) an expanding vegetation coverage coupled with reduced erosion, (ii) a deteriorating vegetation coverage coupled with increased erosion, (iii) two transitional states, one with increasing erosion and vegetation coverage and the other with decreasing erosion and vegetation coverage. With the model, the vegetation-erosion state of the river basin can be quantitatively described, by way of a vegetation-erosion chart, for varying climate, soil and topographic conditions. This paper presents the principles and results of area-specific investigations that track the fractions of the areas covered by vegetation and experiencing soil erosion (with soil loss determined in t/km2yr).

Key words: Tibetan plateau, Yalutsangpo gGrand Canyon Bio-diversity; Types of erosion; Dry valleys, Vegetation-erosion dynamics