**DSPMU UNIVERSITY, RANCHI.**

**DEPARTMENT OF GEOLOGY**

**M.Sc. SEMESTER-III**

**EQUILIIBRIUM CONCEPT IN GEOMORPHOLOGY**

A ‘**system**’ is a whole compounded of many parts, or ‘a meaningful arrangement of things’ (Schumm 1977, p. 4). By this definition, a hillslope is a system consisting of ‘things’ (rock waste, organic matter, and so forth) arranged in a particular way, the arrangement being meaningful because it is understandable in terms of physical processes. Other definitions of systems refer to a set of objects, and attributes of the objects, standing together to form a regular and connected whole.

***“A system is a structured set of objects and/or attributes. These objects and attributes consist of components or variables (i.e. phenomena which are free to assume variable magnitudes) that exhibit discernible relationships with one another and operate together as a complex whole, according to some observed pattern*.”**

(Chorley and Kennedy, 1971, p. 1–2)

All geomorphic systems, (eg. hill slopes) are open systems as they exchange energy and matter with their surroundings. They are also dissipative systems, which mean that irreversible processes resulting in the dissipation of energy (generally in the form of friction or turbulence) govern them.

When a disturbance or a change in driving force (a perturbation) is imposed on a geomorphic system, the system responds to such a change by altering one or many of its components. Discussion of responses to disturbances in the geomorphological literature tends to revolve around the concept of equilibrium. In simple terms, **equilibrium** is ‘***a condition in which some kind of balance is maintained***’, but it is a complex concept, its complexity lying in the multiplicity of equilibrium patterns and the fact that not all components of a system need be in balance at the same time for some form of equilibrium to obtain.

**Equilibrium** is commonly used to describe geomorphic systems that can adjust to changes by reaching a steady state. As a conceptual framework, equilibrium emphasizes the *relation between present form and process*. Several forms of equilibrium occur where landforms or geomorphic processes do not change and maintain static or stationary states.

**Static equilibrium** is the condition where an object has forces acting upon it but it does not move because the forces balance. Examples are a boulder resting on a slope and a stream that has cut down to its base level, so preventing further entrenchment.

**Stable equilibrium** is the tendency of a system to return to its original state after experiencing a small perturbation, as when a sand grain at the base of a depression is rolled a little by a gust of wind but rolls back when the wind drops. Negative feedback processes may lead to the process of restoration.

**Unstable equilibrium** occurs when a small perturbation forces a system away from its old equilibrium state towards a new one. If the disturbance persists or grows, perhaps through positive feedback processes, it may lead to disequilibrium or non-equilibrium. A simple example would be a boulder perched atop a hill; a force sufficient to dislodge the boulder would lead to its rolling down slope.

In **metastable equilibrium**, static states episodically shift when thresholds are crossed. It involves a stable equilibrium acted upon by some form of incremental change (a trigger mechanism) that drives the system over a threshold into a new equilibrium state. A stream, for instance, if forced away from a steady state, will adjust to the change, although the nature of the adjustment may vary in different parts of the stream and at different times. In the simplistic cause-and-effect view of landscape evolution, changes are seen as a simple response to an altered input. It shows that landscape dynamics may involve abrupt and discontinuous behaviour involving flips between quasi-stable states as system thresholds are crossed.

In another common form of equilibrium, a geomorphic system self-maintains a constant form or steady state in the face of all but the largest perturbations. An example is a concavo-convex hill slope profile typical of humid climates with a concave lower portion and a convex upper slope, where erosion, deposition, and mass movement continue to operate, and the basic slope form stays the same. Such **steady-state equilibrium** occurs when numerous small-scale fluctuations occur about a mean stable state. The notion of steady state is perhaps the least controversial of systems concepts in physical geography. Any open system may eventually attain time-independent equilibrium state – a steady state – in which the system and its parts are unchanging, with maximum entropy and minimum free energy. In such a steady state, a system stays constant as a whole and in its parts, but material or energy continually passes through it.

As a rule, steady states are irreversible. Before arriving at a steady state, the system will pass through a transient state (a sort of start-up or warm-up period). For instance, the amount of water in a lake could remain steady because gains of water (incoming river water and precipitation) balance losses through river out flow, ground- water seepage, and evaporation. If the lake started empty, then its filling up would be a transient state.

**Thermodynamic equilibrium** is the tendency towards maximum entropy, as demanded by the second law of thermodynamics. In geomorphology, such a tendency would lead to a continuous and gradual reduction of energy gradients (slopes) and an attendant lessening of the rates of geomorphic processes. A featureless plain would be in a state of thermodynamic equilibrium, but virtually all landscapes are far removed from such an extreme state.

**Dynamic equilibrium** is quite a disputed term. Geomorphologists have used this concept to represent different scenarios. Currently, dynamic equilibrium is synonymous with a ‘steady state’ or with a misleading state, where the **system appears to be in equilibrium but in reality it is changing extremely sluggishly**. Thus, the term has been a replacement for such concepts as grade.

In **dynamic meta-stable equilibrium**, thresholds trigger episodic changes in states of dynamic equilibrium (dynamic equilibrium meaning here a trending mean state). So, dynamic metastable equilibrium is a combination of dynamic and meta-stable equilibria, in which large jumps across thresholds break in upon small-scale fluctuations about a moving mean. For this reason, dynamic metastable equilibrium is really a form of disequilibrium as a progressive change of the mean state occurs.

