

TOPIC: -

MORPHOGENETIC REGIONS.



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MORPHOGENETIC REGIONS.

Regions – formal and functional are concepts that have been used by geographers to categorize the different areas of the world on basis of some unifying element. In physical and human geography both regions have been profusely used such as natural regions, climatic regions, linguistic regions, cultural regions etc. Morphogenetic regions are those in which the climatic phenomena give a pronounced distinction to the landforms and the geomorphic processes.

Regions: -

Region is a dynamic concept which has been described differently by geographers on the basis of distinct characteristics. It is a homogeneous area on the earth surface marked with similar characteristics making it different from other areas for geographers. Concept of region is very useful as it helps in organizing different attributes accordingly and thus making vast amount of information simple so that it can be understood on the basis of different spatial perspective.

Famous French geographer Vidal de la Blache called areas with similar physical and cultural characteristics as 'Pays'. Widely accepted definition of region is "an area having the homogeneity of physical and cultural phenomena". The basic idea of classification of region is to show homogeneity of geographical features making it distinct individually on the basis of different features like vegetation, soils, climatic factors, structure, industrial resource regions, agricultural regions, settlements and distribution of population. Thus, through regions, geographers attempt to show distinct individuality with unique characteristics of the region. Concept of region can be universally applied and it is divided into two main categories - Formal Region and Functional region

Formal region: -

It is an area which has one or more characteristics in common. These shared characteristics can be at physical level (topography, soil, climate, vegetation, relief); at cultural level (language, religion, and ethnicity); and organizational phenomena (socio-economic institutions).

Best example of formal region is continents like Europe, Asia and Africa having distinct boundaries. Another example is equatorial region, tropical region, temperate region, tundra region which is characterized so on the basis of temperature and rainfall. Morphogenetic region is also example of formal region where it is classified on the basis of temperature and precipitation.

Functional Region: -

Functional region are spatial systems which is defined on the basis of interactions and connections giving it a dynamic and organizational basis. It is organized in such a way that it functions as a single unit in terms of political, social and economic aspect. These are the focal regions which are connected by various systems such as transportation, communication and economic activities. 'City region' is the best concept of functional region. The city region is "an area of interrelated activities, kindred interests and common organizations, brought into being through the medium of the routes which bind it to the urban Centers". NCT of Delhi is example of functional region as it serves as the focal point of all the economic, political and social activities catering to the surrounding region.

Geomorphology and Climatic Geomorphology: -

While it is important to contextualize regions both formal and functional and understand the nature of morphogenetic region, it is pertinent to relate to themes of geomorphology and climatic geomorphology differently. Geomorphology is derived from geo- earth, morpho-form and logis-discourse. Geomorphology is the science which deals with the study of origin and development of landforms like sand dunes, caves, hills and valleys and how all the landforms contribute to their formation of landscape. The core elements of the subjects include evolution, change and analysis of landforms. Geomorphological studies include the quantitative analysis of landform shapes, the monitoring of surface and near-surface processes like running water, ice, wind that shape landforms, and the characterization of landform changes that occur in response to factors such as tectonic and volcanic activity, climate and sea level change, and human activities. Davisian concept (1899) of "Landform as a function of structure, process and time" provided the foundation basis of the geomorphic study of landforms from structural, geomorphologic point of view and to understand the erosion cycle.

The various denudational process taking place on earth's surface is affected by climatic factors. Taking the importance of climate in sculpturing the landscape, a branch of investigation of geomorphology known as climatic geomorphology has evolved. Climatic geomorphology can be

defined as the discipline that identifies climatic factors such as intensity, frequency and duration of precipitation, frost intensity, direction and power of wind, and it explains the development of landscapes under different climatic conditions. Earlier, the study of geomorphology has focused on the analysis of the sequence and nature of geomorphic events involved in the present configuration of the Earth's surface through geological time. Some geographers called this approach as historical geomorphology. The study of the working processes at smaller level, together with the analysis of landform variability, has resulted in the quantitative or processes geomorphology.

Morphogenetic Regions: -

Morphogenetic region is theoretical concept propounded by various geomorphologists to relate landforms and geomorphic process with climate. This as a concept was first proposed by German geographer Julius Budel in 1945. This concept asserts that under certain set of climatic circumstances, different sets of geomorphic processes predominate and produces distinct topographic features. This theory is based on the assumption that rock type resistant to erosion is dependent on the climatic conditions to which it is subjected. Now, it becomes clear by analyzing different factors that these landform features result from the interaction of rock type, physical processes and more predominantly climatic phenomena.

In general, morphogenetic regions are large areas with distinct geomorphic processes (like weathering, frost action, mass movements and wind action) which operates and tends towards state of morphoclimatic equilibrium. It is an area where landforms are shaped by similar processes more particularly by climate. In this, the distinctive morphogenesis of an area is investigated. According to Chorley et al (1984), “the extent to which different climatic regimes are potentially capable of exerting direct and indirect influences on geomorphic processes and thereby of generating different ‘morphogenetic’ landform assemblages”. For this, sometimes climate-morphogenetic regions are also used. Penck in 1909 used Arid, Humid and Nival as the name for zones with distinct climate, hydrology and geomorphology. Earlier, he recognized that these regions have shifted their earlier position during the warm and cold periods of Pleistocene and later in 1913, he introduced the term ‘pluvial’.

According to Peltier morphogenetic regions are those geomorphic areas that are characterized by climatic regimes “within which the intensity and relative significance of the

various geomorphic processes are ... essentially uniform.” They are defined broadly in terms of temperature versus rainfall, and nine types of such regions were identified by him. Peltier also defined the main geomorphic agents, showing climatic fields of weaker or stronger action.

“The concept of a morphogenetic region is that under a certain set of climatic conditions, particular geomorphic processes will predominate and hence will give to the landscape of a region characteristics that will set it off from those of other areas developed under different climatic condition. Morphogenetic regions are conceptual tools by which a geomorphologist relate climatic phenomena, process, landforms and regions.

The morphogenetic concept does not directly identify those features of the landscape which replicate factors other than process and climate. Thus, landforms whose origin is largely tectonic, lithological, structural, volcanic are not considered under morphogenetic classification, but are discussed under the general heading of morpho structure. Also excluded are landforms which reflect processes that are relatively independent of climate like wave-produced features. This type of classification takes into account region in which a distinctive complex of erosional, transformational and depositional processes is responsible for landform development. The system approach giving emphasis on process measurement and the relation between process and form has been successful in identifying many features of landscape that appear to show consistent relationship between inputs and outputs or form.

Morphogenetic processes that forms the landform from earth materials are classified into two types- endogenetic and exogenetic. The endogenetic processes are energy forces which act within the crust of the earth and it includes crustal or non-isostatic warping within the mantle causing earthquake, folding, faulting, metamorphism etc. The exogenetic processes means phenomena which acts outside of the earth’s crust and it covers erosion and weathering and other surface processes under climatic influence. The duration, frequency and effectiveness of geomorphic processes record wide distinguishing features in long-time unit that are reflected on landforms. The maturity and chronological sequence of landforms as well as the depositional pattern help reconstruction of climatic changes. However, while analysing the sequence of fluvial or slope deposits, it may be concluded that the deposition represents only a small fragment of time and on

the contrary much longer time intervals are reflected in a hiatus or in erosional surfaces.

Peltier, 1950 produced a process-based classification of so-called 'morphogenetic regions' based on an analysis of the ranges of temperature and precipitation within which six major geomorphic processes operate. Peltier identified the following nine regions.

1. Glacial—average annual temperature range 0–20°F; average annual rainfall range 0–115 cm. Dominant processes- glacial erosion, wind action and nivation.
2. Periglacial—average annual temperature range 5–30°F; average annual rainfall range 10–140 cm. Dominant processes—strong mass movements, moderate to strong wind action and weak fluvial action.

Peltier identifies a distinct periglacial cycle in cold, humid, subarctic regions associated with the production of three coexisting erosion surfaces:

- (a) A surface of down wasting produced by congeliturbation
- (b) A surface of lateral planation produced where the water table and the zone of frequent nivation coincide
- (c) A stream graded, or aggraded, surface.

Davis regarded periglacial action as a climatic accident but Peltier followed Troll in believing its characteristics to be sufficiently significant and persistent to be separately categorized. Peltier considered each cycle (including the periglacial (Troll 1948) to be normal within its own regime and an accident only when one morpho climate temporarily encroaches on another regime. The question remained, however, as to whether periglacial conditions have persisted long enough in any one locality to produce a distinctive set of landforms, as distinct from 'mere embroidery' of the landscape.

3. Boreal—average annual temperature range 15–38°F; average annual rainfall range 10–60 inches. Dominant processes—moderate frost action, moderate to slight wind action and moderate fluvial action. Essentially Kappen's Dfc region.
4. Maritime—average annual temperature range 35–70°F; average annual rainfall range 50–75 inches. Dominant processes—strong mass movements and moderate to strong fluvial action. It has been pointed out that Peltier's regions 3 and 4 have no dominant geomorphic characteristics to distinguish them from regions 2 and 6.

5. Selva—average annual temperature range 60–85°F; average annual rainfall range 55–90 inches. Dominant processes—strong mass movements, slight slope wash and no wind action. This humid tropical morphoclimate was based on the work of Bornhardt, Sapper, Freise and Cotton.
6. Moderate—average annual temperature range 35–85°F; average annual rainfall range 35–60 inches. Dominant processes—strong fluvial action, moderate mass movements, slight frost action and no significant wind action. This approximated to Davis’ (1899H) ‘normal’ cycle.
7. Savanna—average annual temperature range 10–85°F; average annual rainfall range 25–50 inches. Dominant processes—strong to weak fluvial action and moderate wind action (Cotton 1942, 1961).
8. Semi-arid average annual temperature range 35–85°F; average annual rainfall range 10–25 inches. Dominant processes—strong wind action and moderate to strong fluvial processes. Includes the dry continental regions (Cotton 1942).
9. Arid—average annual temperature range 55–85°F; average annual rainfall range 0–15 inches. Dominant processes—strong wind action and slight fluvial and mass movement processes.

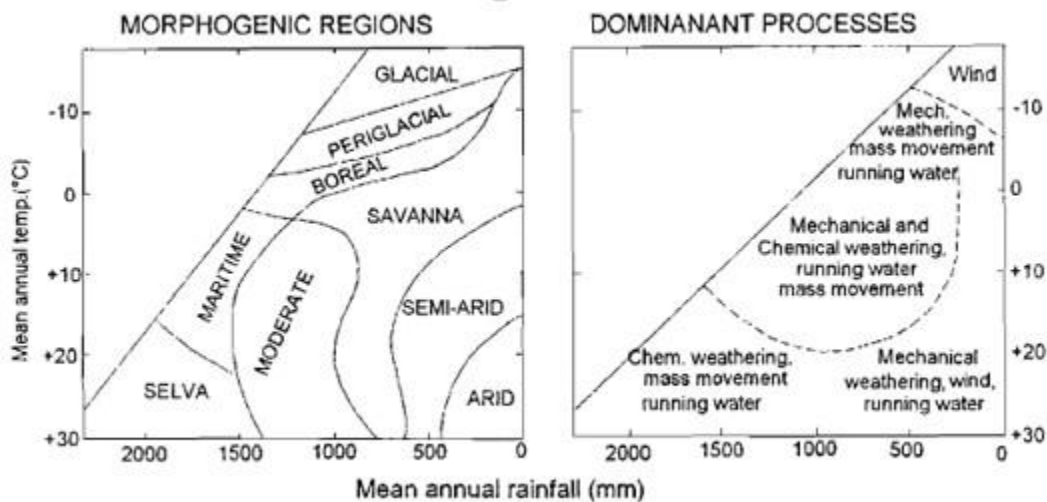


Figure 1: Morphogenetic Regions and Dominant Processes (Related to Mean Annual Rainfall and Mean annual temperature)

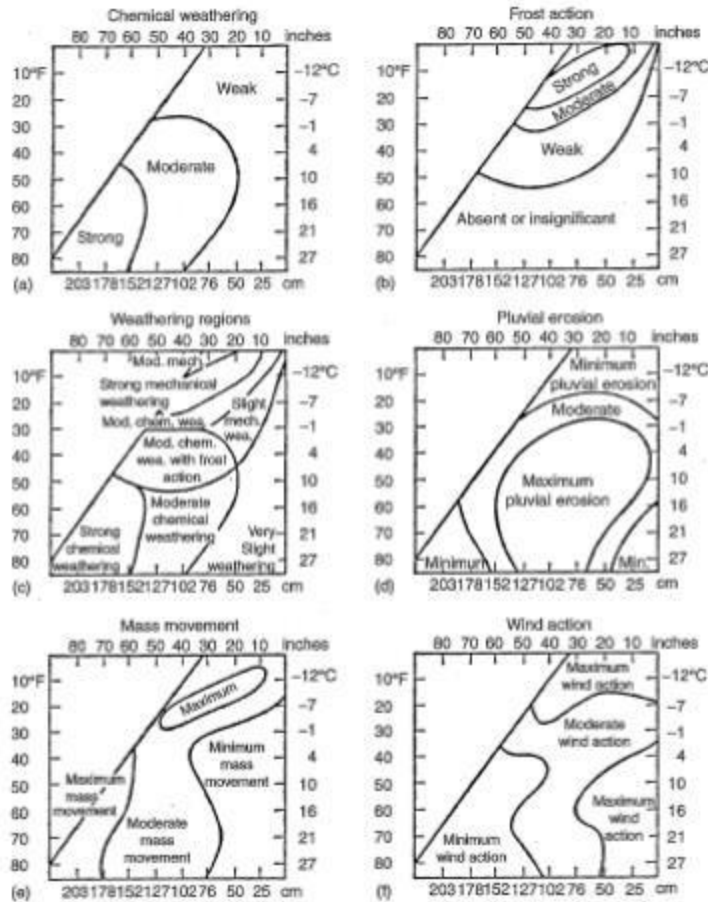


Figure 2: “Peltier diagrams” illustrating the relative importance of some geomorphic processes as a function of mean annual rainfall and temperature.

Morphoclimatic Zones: -

In 1948, German geographer Budel introduced the system of climatic geomorphology (Das System der klimatischen). He has given a descriptive analysis of the distinctive processes associated with each morphoclimatic zone. The most important aspect was the interrelationship of the processes in one zone, that is, the work of the river is dependent on the relief of the area and further the precipitation controls the amount and time of discharge. The load transported by river streams generally depends on slopes and creeks.

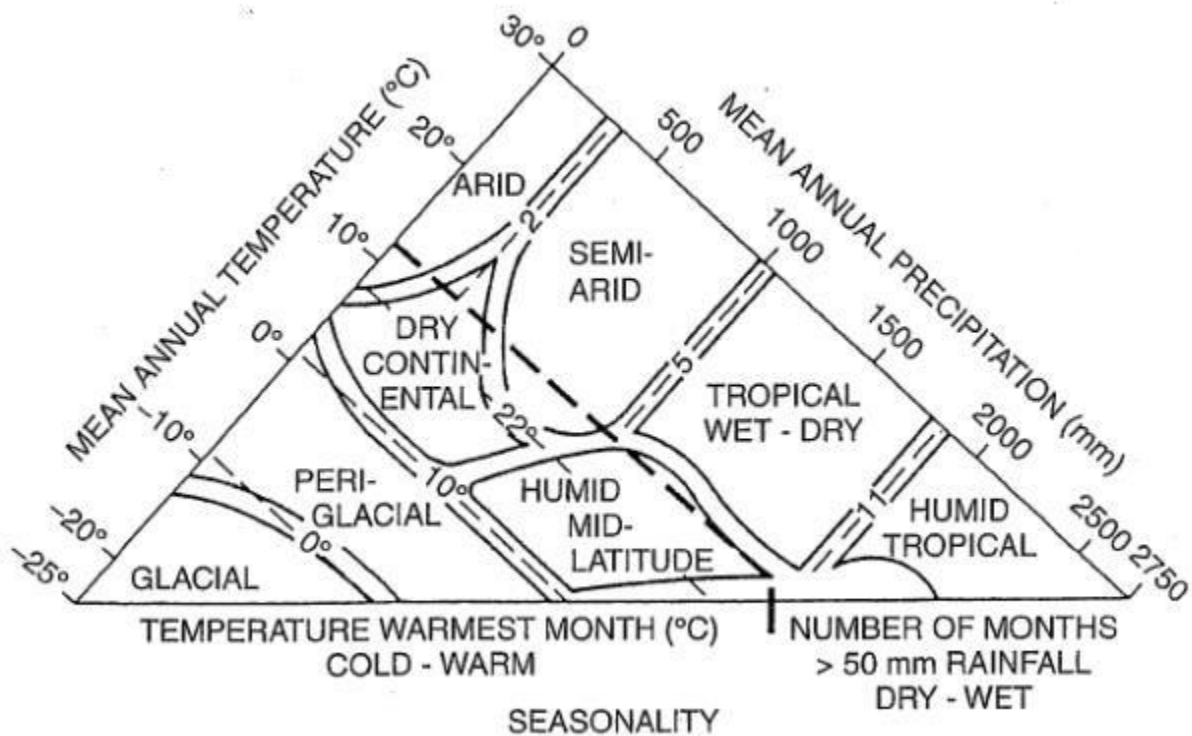


Figure 3: Main morphoclimatic zones classified according to mean annual temperature (°C), mean annual precipitation (mm), mean number of wet months (>50 mm) and mean temperature of the warmest month (°C).

A simplified morphoclimatic classification proposed by Köppen is based primarily on regional classification of vegetative significance with the combination of temperature and precipitation which has given climatic expression to geomorphological significant process. On the basis of this, he identified 6 regions designated by capital letters – A, B, C, D, E and H. These major regions have been subclassified using lower case alphabets on basis of precipitation (s, w, f, m) and temperature (a, b, c). These were grouped to generate eight morphoclimatic regions, which fall into two groups wherein the major geomorphic processes are either non-seasonal or seasonal.

- A) **Non-seasonal category** includes the glacial, arid and humid tropical. These have non-seasonal processes normally having low average erosion rates, highly infrequent and episodic erosional activity like desert rainstorms, glacial surges and slope mass failures and a tendency for the location of their cores to persist latitudinally (at 90° 25° and 0°, respectively) during climatic changes, even if the climatic type is completely obliterated on occasions.
- B) **Seasonal group** includes tropical wet-dry, semi-arid, dry continental, humid mid-latitude and periglacial regions. These have processes which are more specifically seasonal in their operation with places having high average erosion rates; erosional activity though episodic shows some consistency over a period of years; and a tendency for considerable changes of their size and location accompanying global climatic changes. Such regions are divided into two groups:
- i) warmer climates (tropical wet-dry and semi-arid) where geomorphic processes differ most significantly in terms of the length of the wet season.
 - ii) cooler climates (dry continental, humid mid-latitude and periglacial) whose geomorphic processes differ mainly in respect of summer temperatures, as well as with some regard to precipitation amounts.

Using the classic Davisian cyclic basis, **C.A.Cotton** (1942) identified six morphoclimatic regions including four main types and two transition types, each with characteristic mature landforms.

1. Normal (main)—applying to humid temperate landforms.
2. Glacial (main)—include Davisian glacial cycle but excludes periglacial landforms.
3. Humid tropical (transitional)
4. Arid (main)—landforms dominated by interior drainage like bajada and pediment extension, basin capture, slope retreat and the replacement of desert mountains by low domes. Fluvial (sheet flood and stream flood) processes dominate but are increasingly assisted through time by Aeolian processes. A sharp break appears to exist between the hillslope (30–35° or more), on the one hand, and the pediments (5–7° in the higher parts and 3–4° in the lower ones) and the virtually flat bajadas, on the other.
5. Semi-arid (transitional) — it is difficult to distinguish from arid conditions in terms of processes but with the upper pediment slopes being steeper and breaks of slopes less abrupt.

The semi-arid morphoclimatic region is much difficult to distinguish from the arid and the savanna regions.

6. Savanna (main)—showing the flat plains and abrupt inselbergs.

A more refined morphoclimatic classification was proposed by **Büdel** (1944, 1948b). Underlining the intricacy of the climatic processes controlling landforms (e.g., number of frost-thaw cycles), Büdel argues that major landforms change more slowly than climate (and are thus relics of numerous past climates) and that any attempt to link present-day climate and landforms must concentrate on those forms which are small scale and rapidly evolving. He proposed the following morphoclimatic classification involving eight terrestrial regions and ten subregions:

1 Glacier zone

2 Frost-rubble zone (Frostschuttzone)

3 Tundra zone

4 Extra-tropical (mature: in situ) soil zone (Nichttropische Ortsbödenzone)

(a) maritime temperate zone

(b) Sub polar tjäle-free (sub polar without permafrost)

(c) tjäle zone (sub polar with permafrost)

(d) continental zone

(e) steppe zone

5 Mediterranean transition zone (Etesische Übergangszone)

6 Arid-rubble zone (Trockenschuttzone)

(a) tropical inselberg-pediment desert zone

(b) extra-tropical desert zone

(c) high-altitude (cool) desert zone

7 Wash-plain zone (humid savanna) (Flächenspülzone)

(a) tropical wash-plain (sheetwash) zone

(b) sub-tropical wash-plain (sheetwash) zone

8 Inter-tropical mature equatorial soil zone (Innertropische Ortsbödenzone)

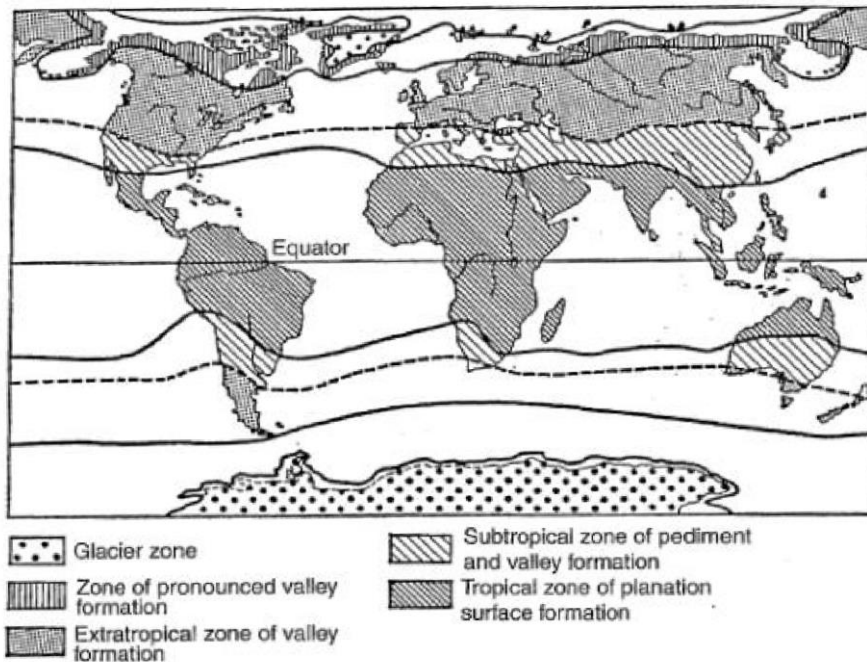


Figure 4: Distribution of the present-day major morphoclimatic zones of the Earth according to Büdel (1963).

This type of classification created wide interests among geographers though it was criticized for many reasons. Firstly, due to its Azonal organization; subdivision of permafrost between frost, tundra, sub polar with permafrost; Grouping of taiga and permafrost with maritime forest and steppe and lastly the separate identification of the Mediterranean landforms.

Tricart and Cailleux (1955, 1965) proposed the following classification of morphoclimatic zones. According to them, Vegetation type is an indirect impact of climate. Under the given climatic conditions, the plant cover modifies the morphogenetic processes, but in turn the latter impact the ecologic conditions of the region and thus, there is an impact on vegetation.

1. The cold zone.

(a) Glacial

(b) Periglacial (later subdivided into five by Tricart).

2. The mid-latitude forest zone (affected by past climates, particularly Pleistocene, and by human activity).

- (a) Maritime (relict Pleistocene glacial and periglacial forms survive).
 - (b) Continental (Pleistocene permafrost may survive).
 - (c) Mediterranean (relict Pleistocene periglacial forms least important)
3. The dry zone. Subdivided on bases of:
- (a) Water deficiency into steppe, xerophytic bush and desert;
 - (b) Winter temperatures into cold and warm.
4. The humid tropical zone.
- (a) Savannas, affected by earlier drier conditions, evidences of semi-arid pediplanation and of climatic changes in the form of 'cuirasses' (i.e., laterites, calcretes and silcretes).
 - (b) Tropical rain forests.

From these broad morphoclimatic zones, **Tricart and Cailleux** (1965 and 1972) developed a classification of world morphoclimatic regions in which morphoclimatic and morphogenetic (i.e. relict) influences are not clearly distinguished:

- 1 Glacial regions;
- 2 Periglacial regions with permafrost;
- 3 Periglacial regions without permafrost;
- 4 Forest on Quaternary permafrost;
- 5 Maritime Forest zone of mid-latitudes with mild winters;
- 6 Maritime Forest zone of mid-latitudes with severe winters;
- 7 Mid-latitude forest zone of Mediterranean type;
- 8 Semi-desert steppes:
 - (a) Semi-desert steppes with severe winters;
- 9 Deserts and degraded steppes without severe winters;
- 10 Deserts and degraded steppes with severe winters;
- 11 Savannas;
- 12 Intertropical forests;
- 13 Azonal mountain areas.

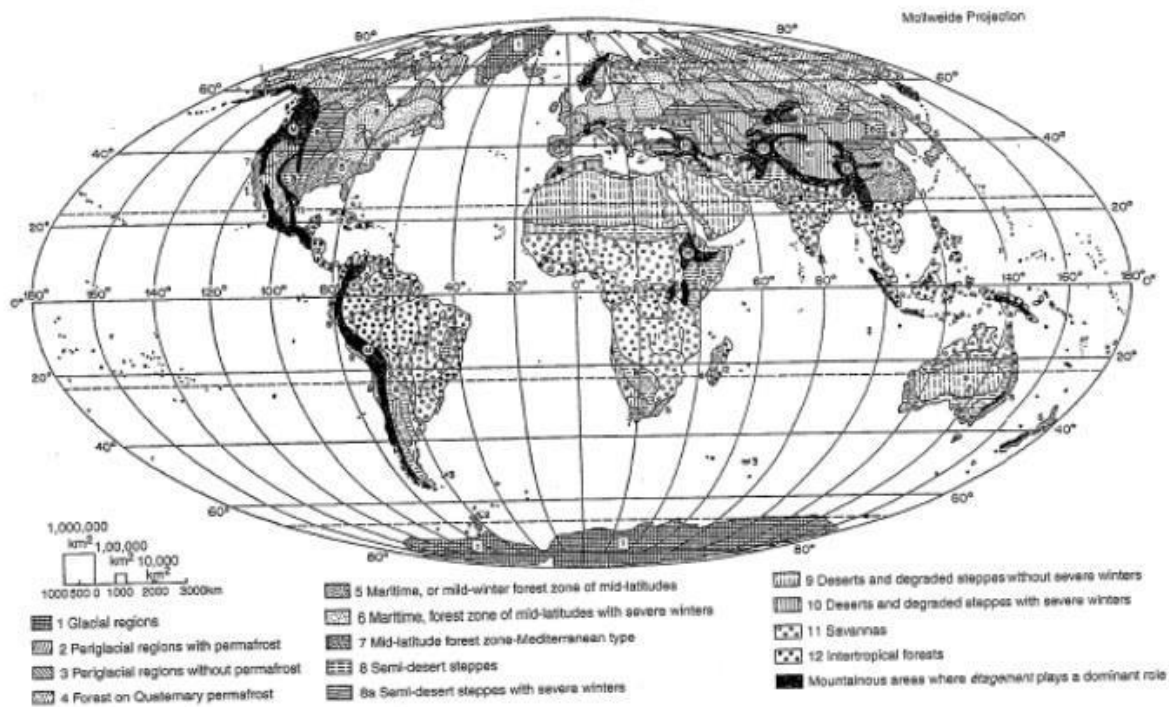


Figure 5: Distribution of the morphoclimatic zones of the Earth proposed by Tricart and Cailleux, (1965).

Source: Tricart and Cailleux, (1965) and (1972) Figure 8, pp. 172–3. Courtesy SEDES, Paris and Longman Harlow

As per Budel(1948, 1982), the geographers have identified morphoclimatic and morphogenetic regions differently. Wilson identifies 5 regions, Peltier – 8, Flohn – 8, Köppen -11, Strahler – 14, Trewartha – 16, Thornwaite – 18. Finally, the following Table presents a broad classification of morphogenetic region that has been devised by combining the distinct climatic characteristics, the geomorphic process and nomenclature as given by Köppen.

Morphogenetic Regions	Other Name	Koppen Region	Geomorphic Processes							Morphological Features
			Frost Weathering	Mechanical Weathering	Chemical Weathering	Mass Wasting	Fluvial Processes	Glacial Scour	Wind Action	
Glacial	subglacial, nival, cold humid, arctic	EF	Maximum	Moderate	Minimum	Minimum	Minimum except for Seasonal meltwater	Maximum	Maximum	alpine topography, abrasion surfaces; kames; eskers; till forms; fluvio-glacial features.
Arid	desert; tropical and subtropical desert, hot dry desert, arid rubble	BWh	Minimum except at High Altitude	Maximum especially salt and thermal	Minimum	Minimum	Minimum except gullying and sheetwash	Negligible	Maximum	dunes; playas; deflation basins; angular, debris covered slopes; fossil fluvial forms (e.g. fans and arroyos).
Humid Tropical	selva; rain forest; inner tropical zone, intertropical	Af and Am	Negligible	Minimum	Maximum giving thick, fine-grained debris even on steep slopes covered with thick vegetation	Maximum but highly episodic and irregular on steep slopes, especially in the form of earthflows and slips	mod.—min. slopewash and rainbeat; min. stream corrosion due to lack of coarse debris; max. chemical and suspended-load transport	Negligible	Negligible	low-gradient rivers; wide, flat or gently undulating floodplain floors up to several kilometres wide; steep slopes (frequently greater than 40°) rising abruptly from valley floors, stabilized by dense vegetation but susceptible to infrequent landslides; knife-edged ridges maintained by parallel retreat of steep slopes.
Tropical wet Dry	savanna; tropical sheetwash zone; moist and dry savanna; tropical savanna, wash plain, dry season	Aw and Cw	Negligible	Minimum	seasonal max.—accelerated by standing water, giving deep weathering and two weathering zones, at the surface and at the weathering front; surface crusts of Al and Fe generated during dry seasons	Maximum	mod.—max.—highly seasonal sheetfloods, rill wash and channel flow	Negligible	Minimum	steep irregular slopes of coarse debris retreating parallel by basal chemical weathering and sheetflood removal; wide planation surfaces (less than 3.5°) bounded by steep slopes and inselbergs; irregular bedrock surfaces broken by inselbergs and tor-like features probably produced by stripping along the weathering front; badlands on shales and other impermeable rocks.
Semi-Arid	peripheral or marginal hot deserts; desert margins; thorn savanna; semi-desert; semi-arid steppes; Mediterranean or summer-dry subtropical zone (lower-latitude parts only), dry season, arid rubble (part)	BSh and Cs	Minimum except at High Altitude	Semi-moderate especially thermal and salt	Semi Moderate	Moderate	Maximum but episodic in the form of sheetwash	Negligible	Moderate	pediments (1–4°) backed by cliffs and angular talus slopes (25–35°) and inselbergs; integrated ephemeral stream systems; arroyos; badlands; alluvial fans; local dunes.
Dry continental	steppe zone; mid-latitude grasslands; semi-arid steppes; degraded steppes; extratropical deserts (part); savanna (part); cold, dry interior and high deserts, extratropical (part), semi-arid (part)	BSk, BWk and Cfa(part)	Semi moderate but highly seasonal with bedrock affected at times	Semi-moderate	Semi Moderate	Moderate but seasonal activity important	mod.—max., especially in the form of spring and summer sheetwash and gullying	Negligible	moderate, fossil loess in places	pediments flanked by steep, scree-covered slopes; badlands; alluvial fans; arroyos; like tropical wet-dry landforms, these may not appear to differ greatly from the semi-arid ones, but processes may do so (especially those associated with frost and spring thaw).
Humid mid-latitude	oceanic and continental zones of mature soils; temperate marine and continental regions; moist subtropical; humid temperate; maritime; mid-latitude forests; Mediterranean zone and summer-dry sub-tropical (higher latitude parts only); moderate (part); forest on Pleistocene permafrost (part), normal, extratropical (part), marginal monsoon (part), humid	Cfa (part), Cfb, Cs (part), Dwa (part), Dfa (part), Dfb and Dfc (part).	min.—max., especially in higher latitude and continental location where this region is transitional with the periglacial region	Semi-moderate	moderate	mod.—max., creep dominant	moderate	negligible except on mountains and as fossils	minimum	smooth, soil-covered slopes; ridges and valleys; streams with wide range of grain sizes.
Periglacial	frost debris zone; tundra; subpolar zone; high arctic barrens; forest with permafrost; humid microthermal; boreal (part); mature soil zone with permafrost; frost rubble zone, boreal (part)	ET, Dw (part), Dfa (part) and Dfc (part)	max., permafrost conditions or subsoil freezing during significant parts of the year; many months under snow cover; spring thaw phenomena	Maximum	Minimum	maximum talus creep and solifluction everywhere during the spring and in northern parts during the summer	moderate slopewash and valley cutting concentrated in limited thaw season	minimum except on mountains and recent fossil evidences	mod-max	scree slope (about 25° sometimes gullied), solifluction slopes (15–20°) and cryoplanation surfaces (less than 5°) with residuals rising above them; solifluction lakes and terraces; outwash plains; patterned ground; loess and dunes.

Role of Morphogenetic Regions in Land Use Planning: -

Different morphogenetic parameters like climate, lithology and structure, drainage and slope have direct consequences on the choice of natural land use practices. Thus, it becomes very important to take cognizance of physical limiting parameters while opting for land use planning. But instead of this what actually happens is that physical determinant are ignored and the land use pattern are identified on the basis of economic, social and political. Thus, preceding land use planning, analyses of terrain condition must take place. Terrain evaluation comprises classification of land and creation of databank taking into account all the genetic factors which are necessary for the practical requirements of any land use planning.

Land use pattern of an area is the result of the interrelationship between the people inhabiting the area and their environment. Terrain type and environment determine the land use pattern of an area whereas land use practices itself can contribute to their change of landscape having long term manifestations.

In this module, region – both formal and functional have been expressed. The morphogenetic regions that are formal regions have been analysed in detail, while distinguishing them from the morphoclimatic zones that have been proposed by various climatologists. The integration of climate with geomorphology, operating geomorphic processes and morphogenetic features that finally emerged have been represented in tabular form to get a synoptic view of the morphogenetic regions.