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HYDROLOGICAL APPROACH TO SOIL EROSION MANAGEMENT

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INTRODUCTION

The main factor attempting against the sustainability of agricultural production is soil and land degradation. Also of growing importance are the offsite effects of land degradation on increased risks of catastrophic flooding, sedimentation, landslides, etc, and on global climate changes. Although land degradation is affected by soil and climate characteristics, it is mainly due to unnappropiate use and management of the natural resources soil and water, generally imposed by social and economic pressures. The processes of soil degradation caused by soil-climate-management interactions, generally result on unfavorable and some times drastic changes in the soil hydrological processes.

The problems of soil and water degradation, and derived effects are increasing throughout the world. This is partially due to a lack of appropriate identification and evaluation of the degradation processes and of the relations cause-effects of soil degradation for each specific situation, and the generalized use of empirical approaches to select soil and water conservation practices. The main soil and water degradation processes include soil water erosion (surface and mass movements), soil sealing and crusting, soil compaction, soil and water salinization and sodification, and soil and water pollution. In addition to the negative effects on plant growth and on productivity and crop production risks, soil and land degradation processes may contribute, directly or indirectly to the degradation of hydrographic catchments, affecting negatively the production of hydroelectric power, and the quantity and quality of water supply for the population and for irrigation or other uses in the lower lands of the watershed. Catastrophic flooding, sedimentation and landslides are also rooted on accelerated land degradation.

The processes of soil and water degradation are closely linked through unfavorable alterations in the hydrological processes determining the soil water balance and the soil water regime. They are also conditioned by the climatic conditions and by the use and management of the soil and water resources. Although the close interaction between the conservation of the soil and water resources is increasingly being accepted, still in most of the cases they are evaluated separately, and consequently the prediction and prevention of the effects derived from their degradation are inadequate in many situations. This will become more important under the previewed effects of global climatic changes, which would mainly affect hydrological processes in the land surface, mostly related to the field water balance (Varallyay, 1990).

Global climate change prediction, although still rather uncertain, will increase rainfall in some regions, while others might become drier, in a rather uneven spatial and time distribution. This may contribute to accelerate some land degradation processes leading to larger runoff and erosion, and to increased risks of flooding, landslides, mass movements and mud-flows in tropical regions, and to higher risks of crop production in subtropical and temperate regions. But in any case, land use changes, including deforestation, and other human activities leading to soil degradation processes may affect more the soil hydrological processes and their effects on land degradation, than the previewed global climatic changes, or may increase the influence of these changes. By the contrary, adequate land use and soil and crop management practices may make soils more resistant against the effects of climate changes and derived extreme events.

HYDROLOGY AND SOIL DEGRADATION PROCESSES

The top layer of the soil is the one supporting most of the plant growth, and also the part with higher direct interactions with climate and vegetation, and more influenced by human activities. Climate is probably the main variable that influences, directly or indirectly the topsoil, and particularly the surface layer. Other surface processes are determined by the properties of the soil itself.

Unprotected soil surface is exposed to the direct impact of raindrops, causing disruption of soil aggregates and sealing effects. The most important effect is the reduction in infiltration rates, which may result in runoff and erosion and inefficient use of rainwater in sloping lands, and plant injury due to waterlogging and reduced exchange of gases in flat lands. Although the hydraulic properties of the plow layer and deeper soil horizons are often used as a basis for deducing infiltration, in lands with scarce cover, infiltration and runoff are determined more by the changing soil surface conditions, than by internal soil physical properties. The amount of surface soil removed by runoff water depends to a large extent on the resistance of soil aggregates to be disrupted by the energy of raindrop impact. Runoff induced by seal formation not only poses a problem with respect to soil erosion, but it is also water lost for storage of plant available water in the root zone, which my cause periods of water deficit for the plant, depending on the soil rooting depth and rainfall regime.

In order to optimize the use of rainfall water and to control surface soil erosion, land and soil management practices have to be effective in reducing runoff and erosion, by imparting structural stability to the soil, improving water storage characteristics and reducing sealing. Protecting the soil surface with residues or cover crop against the impact of rainfall, and maintaining high levels of soil organic matter in the surface soil, are the most effective methods of avoiding surface sealing. A possible negative consequence of better infiltration, is the possibility of increased losses of water through the soil profile as internal drainage, and the possibilities of larger transfer of pollutants from the soil to the groundwater.

Shallow compacted layers generally become limiting barriers for root development and for deep percolation and drainage of excess infiltrated rainfall (Pla, 1990). This may affect directly plant growth and crop production, and indirectly increases the risks of soil erosion, waterlogging, and water runoff losses. In some situations compacted layers close to the soil surface may be loosened by tillage to enhance root growth and drainage, but the loosening effects are not lasting in most of the cases.

Among the different land degradation processes, soil water erosion is the major threat to the conservation of soil and water resources. The processes of soil erosion, caused by the interactions of soil, rainfall, slope, vegetation and management, generally result on, or there are caused by unfavorable changes in the soil water balance and in the soil moisture regime, and in the possibilities of root development and activity. Soil erosion processes have direct negative effects on plant growth and crop production, and offsite effects on increased risks of catastrophic floods, sedimentation, landslides, etc. Erosion is exacerbated by deforestation, by introduction of seasonal crops leaving the soil unprotected, by intensification or abandonment of agriculture, by overgrazing, and by improper maintenance of plantations and conservation structures.

Besides surface erosion in gentle to moderate slopes, mass movements and landslide erosion are common in more steep slopes (Pla, 1992; 1993). In surface erosion, the soil particles detached by rainfall or running water, are transported by surface flowing water (surface runoff). Mass movements are the gravitational movements of soil material without the aid of running water (El-Swaify and Fownes, 1992; Crozier, 1986). The hydrological process leading to surface or landslide erosion are different (Pla, 1992, 1997), and therefore, soil conservation practices very appropriate for controlling surface erosion processes may increase erosion danger by mass movements under specific combinations of climate, soil and slope.

Surface erosion is linked with intense precipitation events, high detachability of surface soil material and reduced infiltration. This reduction is induced by poor and week surface soil structure and by poor cover of vegetation or plant residues in critical periods. Under these conditions, generally created by inadequate soil and crop management practices, the surface soil particles are detached by raindrop impact or by running water, and are transported downslope by runoff water, which flows more or less uniformly distributed on the soil surface, or concentrated in rills and gullies of different dimensions.

Mass or landslide erosion generally affects soils with exceptional resistance to surface erosion due to excellent structural and hydraulic properties of the surface soil (Pla, 1992). Sometimes mass erosion occurs on the steep slopes of gullies initially formed by surface erosion processes. Mass movements are generally initiated during and after concentrated and continuous precipitation events, and are associated with prolonged wet periods as a result of persistent antecedent rainfall, in soils with infiltration rates higher than internal drainage, which causes periodic saturation of the overlying soil (Pla, 1997). This erosion process is induced by the marked change in weight and consistence, decreasing cohesion among particles and microagregates, of the surface soil overlying a layer retarding internal drainage. This retarding layer may be a natural pedogenic pan, a litic contact, or a compacted layer produced by inadequate tillage practices. The loss of cohesion and the fluid consistence after wetting close to saturation is more common in the surface layer of some soils like Ultisols and Andosols with very stable microagregates. The water in the close to saturation surface soil is under a hydraulic gradient (depending on water supply and slope), and imparts lubrication to the underlying surface facilitating the sliding of the surcharged overlying soil material.

In deeper unconsolidated sedimentary or volcanic materials or in deeply weathered rocks, with decreasing permeability with depth, the accumulation of internal drainage water below the surface soil cover may lead with time to potential conditions for larger and deeper mass movements. Change in weight and consistence of the surface soil, or deeper materials, cannot in themselves cause a landslide, but they do affect the susceptibility of a sloping land to triggering by some other factor, like earthquakes, removal of downslope (road cuts, etc) or lateral support (gullies, cracks, etc). In natural forested areas the possibilities of shallow landslides are generally much less than in clean cropped areas, and less than in pastures. Forest may have different stabilizing influences, but the main one is the mechanical reinforcement by tree roots, attaching potentially unstable surface soil to stable substrata, and providing a matted network which offers lateral attachment near the surface. Landslide erosion processes or mass movements in general, although occurring less frequently than surface erosion, may lead to much higher and more concentrated soil losses (Pla, 1997), with more dangerous offsite effects.

EVALUATION AND PREDICTION OF SOIL EROSION PROCESSES

An hydrological approach to the evaluation and prediction of the conservation of soil and water against degradation processes would be essential for an adequate development, selection and application of sustainable and effective land use and management practices. The main objective must be to evaluate such hydrological processes, and to select and develop methodologies and techniques to correct or to control them under different conditions of soils, topography and climate. This is required for suppressing or alleviating the negative effects of soil and water degradation on plant growth, on sustainable agricultural production, on the supply of water in adequate quantity and quality for the different potential uses, and on catastrophic events such as flooding, sedimentation, landslides, etc.

Methodology for an adequate quantitative characterization and prediction of the affected soil hydrological properties is required to evaluate the actual problems and to assess the vulnerability of soils to different soil erosion processes. Besides measurements under precise conditions in the laboratory, useful for understanding the hydrological processes, these have to be approximately quantified at field scale. If we intend to use the hydraulic functions to predict or to solve field problems, it is preferable to estimate them from field measurements and experiments. In structured soils, sampling and laboratory measurements are some times more difficult and time consuming than field measurements. Most of the results of experiments with repacked core samples cannot be directly transferred to quantify soil water behavior in the field.

Field measuring techniques are often less accurate and more expensive than in the laboratory, because it is often difficult to rigorously establish boundary conditions, which fluctuate in space and time. This accuracy may be increased with a larger number of directly field-measured hydraulic properties. The objective has to be to obtain approximations acceptable within the limitations of the used methodologies, which can provide practical guidelines for field situations.

Although modern indirect techniques like remote sensing, computerized data processing, GIS and simulation models may help in the required evaluations, they will always require of actualized and accurate direct measurements or estimations of soil hydraulic parameters. Specially needed are better and simpler methods of monitoring important hydraulic properties of soils and their dynamics on a field scale, for both diagnostic and prediction purposes, These properties should be also quantified in terms of the dynamic action of root growth (Larson and Pierce, 1994).

It is generally accepted that for evaluation and prediction of land degradation there are required long-term experiments on a catchment basis. Although this would be desirable, it is not possible if required short-term solutions, as it is usually the case. There are required new approaches based on the evaluation of soil hydrological properties together with historical rainfall records, under different scenarios of changing climate, soil properties, topography and land and crop management (Pla, 1998).

Research on soil degradation has to concentrate more on hydrological and soil degradation processes for interpretation of land degradation problems, with the help of computer-based programs that can be applied to different environments (Pla, 1998). This process-based approach makes the extrapolations more soundly based, and may allow to select or to develop a more adequate package of technologies to reduce soil degradation, while being social and economically acceptable. In any case, it is desirable to keep the information that must be obtained simple, so that basic objectives can be achieved (IBSRAM, 1995). Pressures to change sustainable traditional systems of use and management of land resources must be considered additional parameters (social economic factors) to the biophysical factors in soil degradation processes.

BASIS FOR MODELING HYDROLOGICAL PROCESSES TO GUIDE SOIL EROSION MANAGEMENT

Probabilities and risks of soil degradation and its influence on crop production and environmental damage (Pla, 1994), may be partially previewed with the use of modeling, where the large number of important variables involved in the degradation processes, and their interactions, may be integrated. Direct measurements of runoff and soil loss in the traditional erosion field plots, generally associated to get some of the inputs required by the so called Universal Soil Loss Equation (USLE) (Wishmeier and Smith, 1978), is a slow and costly process, due to the high variability of climate and soils in time and space, which makes it not practical in places where the resources are scarce and there are required short term solutions (Pla, 1991). Therefore, the prediction of water erosion is presently generally done using mostly empirical, and much less process based methods and models. Among these, the USLE, and its derivatives and adaptations, has been by far the most widely used worldwide. These models require local information not available in many cases, which frequently is being substituted by information generated through submodels and regression equations developed under conditions very different to the ones where they are applied. These may lead to great errors in the prediction of soil erosion and selection of conservation practices, with catastrophic results and economical losses in investments and conservation structures.

The presently used empirical models must be replaced with process based event models, which require a better understanding of changing hydrological properties as influenced by soil management, cropping sequences, vegetation, and climate (Foster and Lane, 1987). These models must allow a detailed quantification of hydrological processes for both actual and potential conditions, answering major questions about problems of soil erosion and crop production, related to different alternatives of land management (Pla, 1997; 1998). While they are developed, the main benefit of these models is the identification of gaps of knowledge and data, and the understanding of the soil erosion processes. Process-based prediction models, based on equations that represent fundamental hydrological and erosion processes, including rainfall, infiltration, drainage and runoff, may solve the limitations of the empirical soil loss prediction models, like site specificity, limited transferability and others.

Simulation models based on hydrological processes may be very helpful to integrate and to convert the measured or estimated soil, climate, plant and management parameters into predicted soil water balances and soil moisture regimes for each particular combination of them, actual or previewed. These models may be very simple, or they can be extremely complex, requiring many resources (time, equipment, manpower) and input information which is seldom available, or difficult to determine, or non representative, making less complex models often more suitable for practical purposes. Simulation errors derived from estimation errors in soil properties and the sampling costs are generally lower when simple models are used for predicting water balance in space (Leenhardt et al, 1994). Additionally, simpler models require fewer input data, and therefore they allow larger samples and sampling densities for a given field measurement.

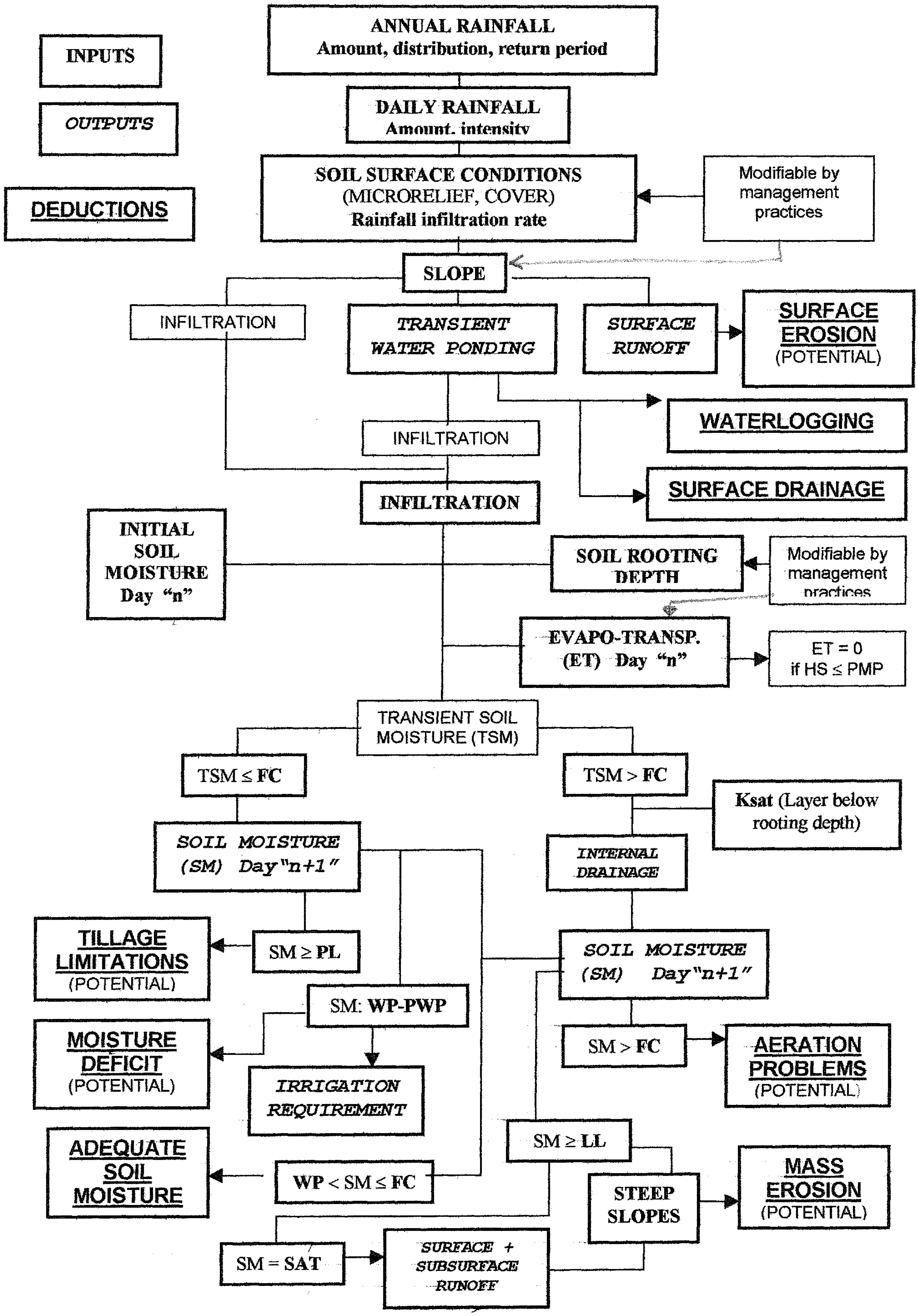
The models used in predicting crop performance, and soil erosion processes derived of the impact of land use and management practices in the soil hydrology, must include weather (mainly rainfall) variability in space and time, and soil properties and their spatial variability.

The required data about soil properties are those influencing water entry and retention in the soil, limits of water retention capacity of the soil, loss of water by evaporation, and environment for root growth.

The flow diagram of scheme 1, which was the basis for the development of the simulation model SOMORE (Pla 1988; 1992; 1997), simulates the evolution of the soil water balance in the soil profile with a time step of one day, using easily obtainable soil and meteorological data as input. It may be used to predict the soil moisture regime, including waterlogging, rainfall losses by surface runoff, and surface and internal drainage, under different conditions of soils, topography, climate, vegetation, crops and management. The model accounts for infiltration of rainfall into the soil as limited by surface sealing effects and limiting layers (natural or induced by management) close to the soil surface, and for internal drainage or subsurface runoff as affected by rainfall infiltration, effective root depth and saturated hydraulic conductivity of the limiting soil layer. The predictions may be used to identify the more probable degradation processes, and for the selection of the best alternatives, with more probabilities of success, of soil and water conservation practices for each combination of soils, climate and topography.

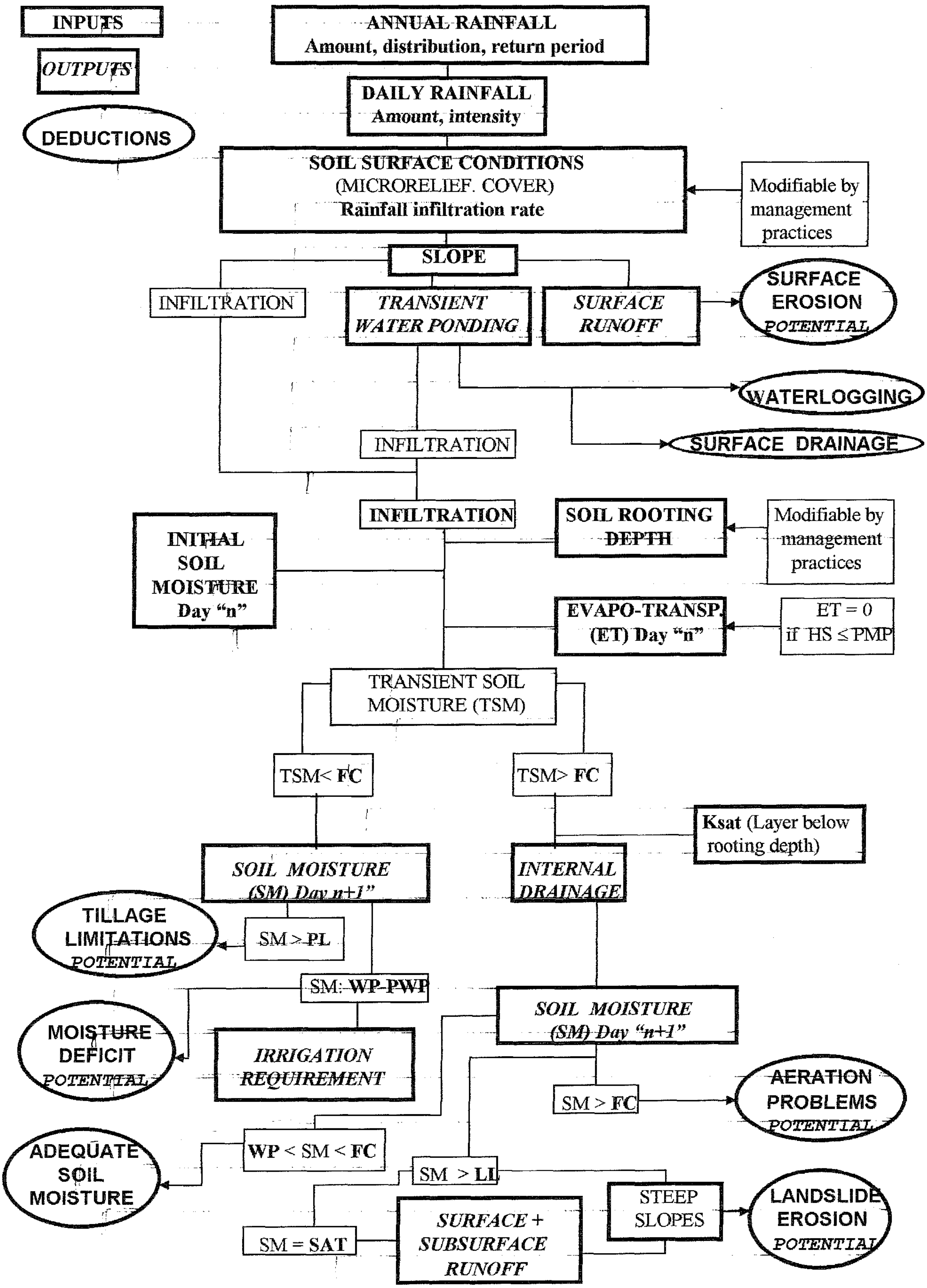
The predicted soil moisture regime may be interpreted in relation to problems of drought or aeration in the overlying soil, at different times and growth stages of natural vegetation or crops, and also in relation to irrigation requirements, possibilities of tillage operations, and erosion hazard by different processes. To preview the possible influences of different combinations of soil and water management on the soil moisture regime, there is required a previous identification and evaluation of the main critical factors affecting problems of soil degradation and of water supply to crops. The variable annual rainfall data, with a particular return period, are used to simulate the behavior of a particular condition or management system in different years, and therefore, based on that previewed behavior, it is possible to select or design, with a probabilistic approach, the best system of soil and water management to control soil erosion (soil erosion management). It is also possible to predict the soil erosion processes and effects, and the problems of water supply to crops, with different return periods, for each condition or proposed land use and management. The selection of certain return periods is important, because they largely determine the requirements of erosion management practices and conservation structures in relation to costs and benefits, for different levels of risk and probabilities of failures.

A particular season or year is described, or analyzed, in relation to the long-term variability, based on rainfall records from the past. The prediction of concentration of surface and subsurface runoff, and of the conditions of soil moisture, would permit to preview which days or periods of the year would have the greatest flood, erosion and sedimentation hazard, and what would be the most probable erosion process (Pla, 1992; 1993; 1997; 1998). This is more useful for designing erosion control strategies than the use of empirical models which have proved not to be able to predict the time and probabilities of occurrence of concentrated runoff and erosion, and much less landslides or mass movements in general.



(Ksat: Saturated hydraulic conductivity; FC: Field Capacity; WP: Water retention at 0,15 Mpa; PWP: Water retention at 1,5 Mpa; PL: Plastic limit; LL: Liquid limit; SAT: Saturation)

Figure 1. Flow diagram of a conceptual hydrological based simulation model to predict the soil moisture regime and to assess the potential soil degradation processes (Pla, 1997a)



Ksat: Saturated hydraulic conductivity; **FC**: Field capacity; **WP**: Water retention at 0.15 Mpa; **PWP**: Water retention at 1.5 Mpa; **PL**: Plastic limit; **LL**: Liquid limit; **SAT**: Saturation

Scheme 1. Flow diagram of a simplified hydrological model (soil water balance in daily time steps) to predict the soil moisture regime and potential soil degradation processes (Pla, 1997a)

CASE STUDIES IN VENEZUELA AND SPAIN

As examples of the potential use of modeling hydrological processes for evaluating and predicting soil and water degradation processes, and for guiding soil and water conservation practices, three situations with different soils, climate, topography, cropping and management conditions are presented. The same approach could be used for any other climatic conditions and combination of soil and management parameters.

The first case, refers to a sandy loam soil (Alfisol) , in rolling lands with a 4-6% slope, under a tropical semiarid climate, with strong seasonal distribution and high variability of rainfall from one year to the other, and within the same year. The traditional use for pastures have changed to continuous cropping of rainfed sorghum, with a length of growing period of 90 - 100 days. The plant residues are usually used as forage for cattle during the dry season. The main constraints for a high and sustained productivity have been identified as soil moisture deficits and surface soil water erosion (Pla 1988, 1997). Sealing effect on bare soil appear to be the main cause of concentrated runoff during intense storms, causing water and soil losses. The root growth is limited by the presence of an argillic horizon at 20-40 cm depth (which gets closer to soil surface after accelerated erosion), and shallow (10-15 cm) clean tillage using mostly disk harrows.

Figure 1 shows the daily moisture regime in a bare tilled soil during the growing period of sorghum, under average rainfall (RP: 2 years) and shallow (20 cm) root depth. The runoff and potential soil erosion - accompanied of flooding and sedimentation in the lower parts of the landscape - are more critical in the first 1/3 of the growing period, while water deficits are concentrated in the last 1/3, coinciding with the critical reproductive and grain formation period. From that we may expect a good vegetative growth, but reduced grain production. Figure 2 shows how the soil moisture regime is affected by soil cover with sorghum residues, preventing runoff (and erosion) and water deficit, even with the relatively shallow (20 cm) rooting depth and average rainfall. In this case we may conclude that the marked surface soil sealing effect is clearly the main cause of concentrated runoff (30-50 % of the total rainfall in the rainy season), of the erosion and of the moisture deficit in bare soil with moderate slopes. The same procedure could be used to explore the potential soil water balances and moisture regimes for other different combinations of climate, crops, effective soil depth, and management practices.

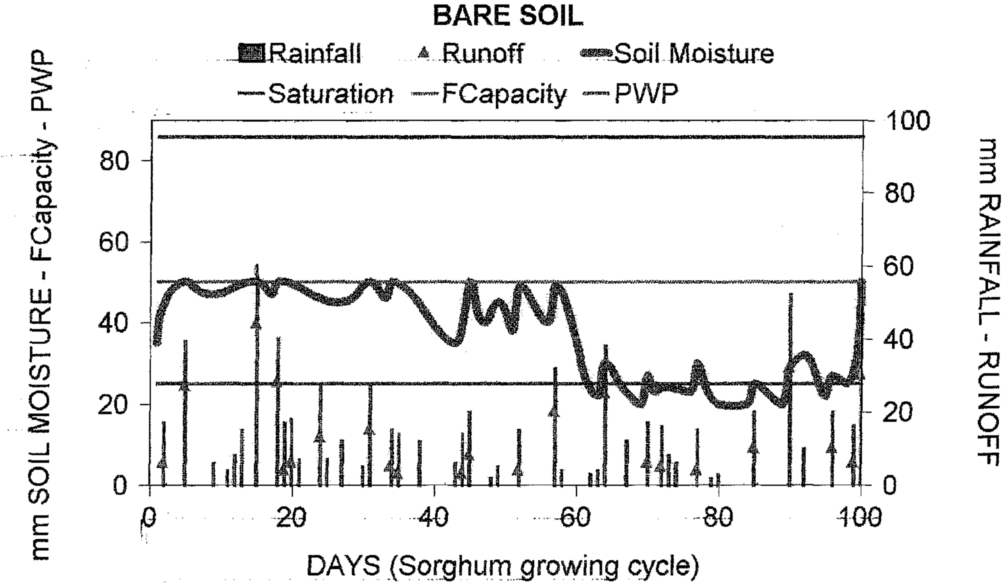


Figure 1.- Soil moisture regime in a bare tilled soil (Alfisol), with a a 4-6 % slope, during the growing period of sorghum, with shallow (20 cm) root depth, in an average rainfall year (return period: 2 years) (Venezuela)

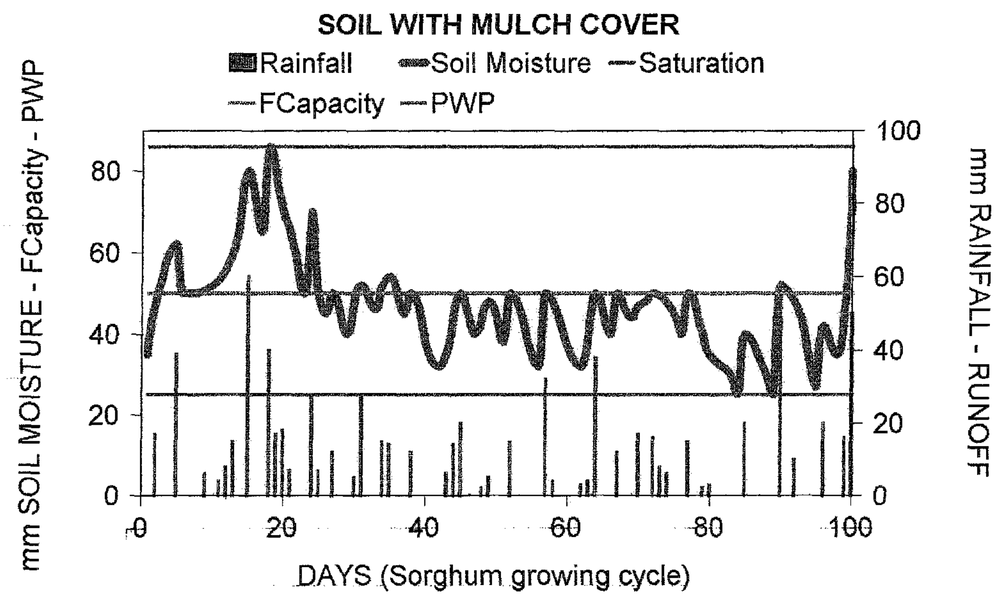


Figure 2.- Soil moisture regime in a soil (Alfisol) in a 4-6% slope, with a mulch (sorghum residues) cover, during the growing period of sorghum, with shallow (20cm) root depth, in an average rainfall year (return period: 2 years) (Venezuela)

The second case, deals with silt-loam soils (Inceptisols), highly calcareous (developed in calcilutites), in lands with undulated-hilly topography (4-20% slope), cropped with rainfed grapevines for wine production, in a Mediterranean semi-arid climate. Most of the agricultural operations, including harvesting, have become mechanized in the last decades, which has required to change the plantation pattern, and to smooth the slopes, and decreasing the irregularities of the original topography. As a consequence of the large earth movements, in most of the cases the soil physical properties affecting infiltration, drainage, and root development have suffered drastic changes. The final effects are increased runoff and soil erosion, and changes in the soil moisture regime at root depth.

Figure 3 (undisturbed soil) and figure 4 (disturbed soil) show how the mechanical disturbance of the original soil affects the soil moisture regime and the potential runoff and erosion processes, during a year (1999), drier than average (return period (RP): 5 years). The approximate correspondence between the simulated soil moisture (S) regime, and the regime based on actual, periodic, soil moisture measurements (Nacci et al, 2000), show how well a model based on simple selected reliable hydrological information may predict actual situations.

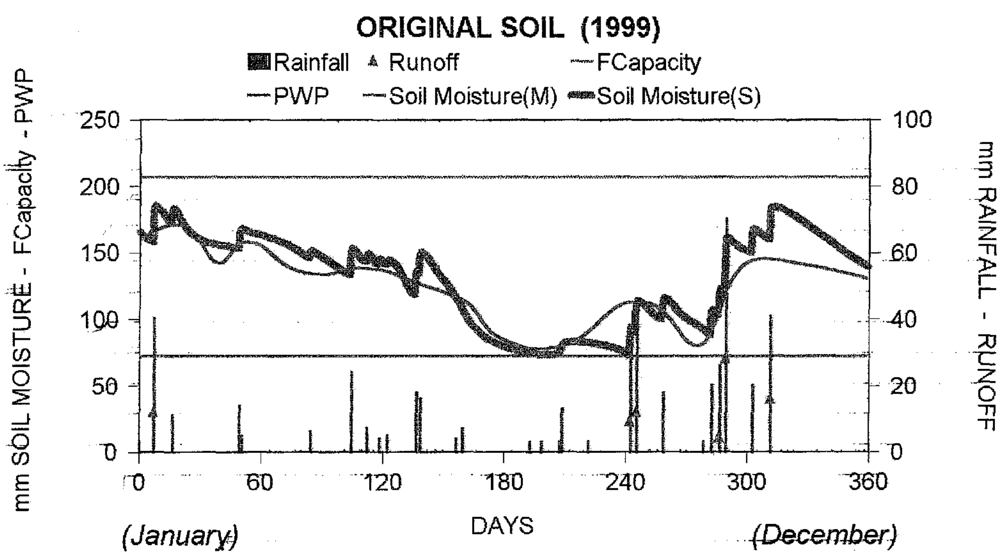


Figure 3.- Soil moisture regime in an undisturbed soil (Inceptisol, 6-10% slope) with vineyards, during a year drier than average (return period: 5 years) and effective root growth at 20-80 cm depth (Spain)
(M: measured; S: simulated)

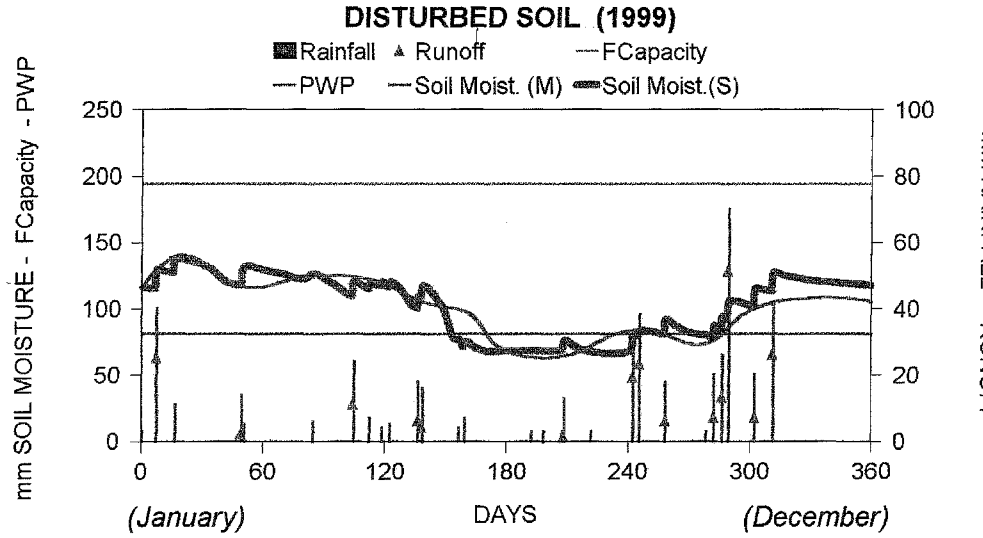


Figure 4.- Soil moisture regime in a mechanically disturbed soil (Inceptisol, 6-10% slope) with wineyards, during a year drier than average (return period: 5 years) and effective root growth at 20-65 cm depth (Spain) (M: measured; S: simulated)

The third example has to do with a clay-loam Ultisol, developed on clay rocks, with very steep slopes (30-50 %), in an area under a tropical humid climate. The land, originally with a dense forest, has been deforested in the last decades to be used for pastures or intense seasonal or annual crops like cassava, sugar cane, etc. Under these new conditions, and due to the presence at 30 cm depth of an argillic horizon with a marked decrease in saturated hydraulic conductivity, there have been developed catastrophic erosion processes, mainly trough landslides and mass movements, in years and periods with concentrated and continuous rainfall events. The surface soil, with microaggregates very stable to wetting and raindrop impact, do not show any sealing effect, and maintain a minimum rain water infiltration rates much higher than the underlying soil bellow 30 cm depth.

Figure 5, shows that in a year with average rainfall (RP: 2 years), even with the contrasting hydraulic properties between the surface soil and the soil at 30 cm depth, we may not expect conditions (prolonged periods with soil moisture above liquid limit and concentrated subsurface runoff) favorable for landslides or mass movements. The combination of a year with high rainfall (RP: 10 years), and the restriction in internal drainage below 30 cm depth (figure 6), create conditions in two periods (30-40, and 135-170 days) of the rainy season, which may lead to accelerated erosion with landslides and mass movements. In this case it may be concluded that the problem of erosion or runoff has nothing to do with surface sealing effects, but it is mainly caused by the combination of high surface infiltration rates, restricted drainage at relatively shallow depth, loss of the anchorage effect of roots from the permanent natural vegetation or crops, and concentration of rainfall events.

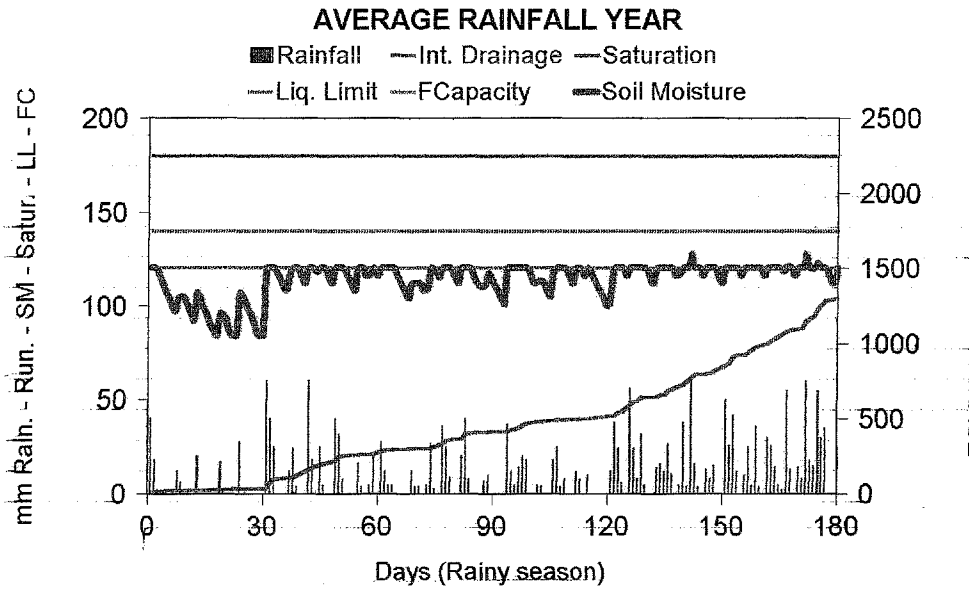


Figure 5.- Soil moisture regime in a grass covered soil (Ultisol), With a clay layer at 30 cm depth, in a very steep slope (30-50%), during the rainy season of an average rainfall year (return period: 2 years) (Venezuela)

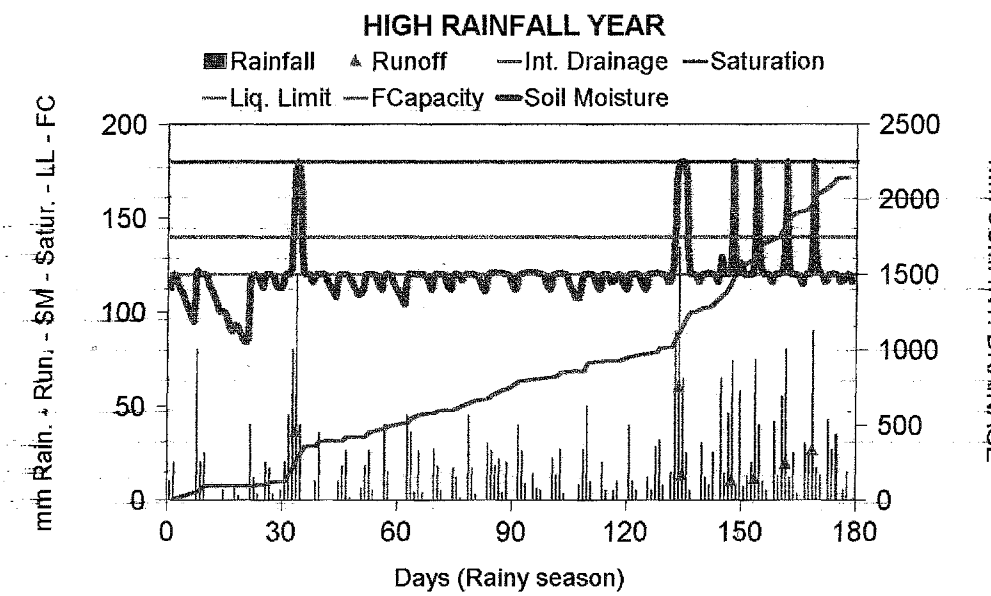


Figure 6.- Soil moisture regime in a grass covered soil (Ultisol), with a clay layer at 30 cm depth, in a very steep slope (30-50%) during the rainy season of a high rainfall year (return period: 10 years) (Venezuela)

CONCLUSIONS

It may be concluded that the estimates of the soil water regime using hydrological based models, may be very useful:

- To diagnose the main factors responsible for the present and future soil water limitations, and the amount and timing of water stress strongly affecting plant growth and crop yields

- To preview the effects of different soil erosion management practices in order to select the most appropriate ones for each case.

This allows to select the long term practices best adapted to the local environment. The model also enables to quantify the weather and soil related variability effects on crops, and to explore ways of matching crops and cropping systems and land management with environment. The aim of soil and water management is not always to increase infiltration, depending on the climate, soil, crop and possibilities of increasing levels of groundwater, groundwater recharge, and use and collection of runoff (water harvesting), and increased risks of mass erosion. In those cases the use of these models also may give an insight to these possibilities.

Besides the examples presented here, there may be many other applications based on the interpretation of the simulated water balances and soil moisture regimes, including the best choice of different crops and varieties, and cropping periods or sequences, and the determination of requirements and the best periods for complementary irrigation, tillage operations, fertilization, application of pesticides, etc, for more effectivity and lower possibilities of pollution of surface or underground waters.

ABSTRACT

The processes of soil erosion, caused by the interaction of soil, rainfall, slope, vegetation and management, generally result on, or there are caused by unfavorable changes in the soil water balance and in the soil moisture regime. Besides surface erosion in gentle to moderate slopes, mass movements and landslide erosion are more common in steep slopes, in bench terraces and in sidewalls of gullies. The hydrological processes leading to surface or landslide erosion are different, and therefore soil conservation practices very appropriate for controlling surface erosion processes may increase erosion danger by mass movements under specific conditions of climate, soil and slope. An hydrological approach to the evaluation and prediction of the erosion processes would be essential for an adequate prevention, control and management of soil erosion and its effects, under different conditions of soil, topography and climate. Simulation models based on hydrological processes may be very helpful for such purpose. Examples of application of that approach to real situations in tropical (Venezuela) and Mediterranean (Spain) climates and soil conditions are presented.

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