PART III

Implications for Model-based Studies of Future Climate Change and Soil Erosion

Chapter 9

ESTIMATION OF SOIL EROSION: IMPLICATIONS FOR FUTURE RAINFALL INTENSITY

9.1 Introduction

By acknowledging the limitation in investigating the effect of rainfall intensity changes on future erosion rates, it is very unlikely that we will be able to predict future rainfall intensity changes and effects of these changes on future soil erosion with reasonable confidences.

If we knew with certainty what the impacts of climate change would be at a local level, then adaptation would be easier; we could say this will be the impact in this location in this year, and then look at what would need to happen to avoid that impact. Unfortunately, we don't, and it is likely that we will unlikely be able to make predictions that are detailed enough and certain enough to make a 'predict and adapt' approach to adaptation a viable option.

However, it may still be possible to draw outlines of future erosion rates using the findings from previous chapters. It may also be possible to simulate how these future rainfall intensity changes will take place and affect soil erosion.

This chapter aims to find out the impact of rainfall intensity changes on "future" soil erosion. The outcomes of this chapter aims to give answers for Research Question 4; *Are we in a position to predict erosion rates under future climates, with different rainfall intensities from the present? If not, what must be done?*

As discussed before, it is impractical to try to predict future erosion at this stage because of the lack of reliable future rainfall data and the imperfection of current erosion models that were found in the previous stages of this research. It may be argued, however, that a guideline could still be drawn out for investigating impacts of rainfall intensity changes on future erosion. In this way, when rainfall data with an acceptable confidence level and better intensity-aware erosion models become available, future erosion may be predicted with a heightened certainty.

Only WEPP was utilised in this part of research because WEPP is the only continuous simulation model from three models used during this research. The other two models (EUROSEM and RillGrow) are what is known as a single event model that is only capable of dealing with a single rainfall event rather than the whole system status that is dynamically updated as the simulation continues over multiple rainfall events. A continuous simulation model—like WEPP—is required to simulate long-term erosion without failing to consider the complex overlap of temporally and spatially diverse distributions of rainfall, erodibility, soil conditions, plant cover and so on (Nearing, 2006).

9.2 Proposed Simulation Methods

Despite the various efforts to find meaningful rainfall intensity trend for building future scenarios of rainfall intensity changes, no significant trend can be determined from analysing observed rainfall data. Knowing future WSIV, WSIP and WSP is vital in order to carry out future erosion predictions. To achieve the aim of this research, an alternative method has to be sought to obtain future rainfall data with a appropriate data scale and 'changed' rainfall intensity. The process of finding alternative method is discussed in this section.

9.2.1 Method One: Changing CLIGEN Generated Data

Daily peak rainfall intensity is changed by changing daily rainfall duration. In a CLIGEN output, R, D, t_p and i_p comprise daily rainfall. These are:

- R : amount (inch)
- D : duration (minute)
- t_p : time to peak (normalised)
- i_p : peak intensity (normalised)

Among these four factors, duration (D) will be adjusted proportionally, keeping other factors such as t_p, i_p and R constant. In this way, the rainfall amount is kept constant, and rainfall intensity is varied.

Thirty year-long climate data were generated using CLIGEN with an input file, which was prepared from the Southover dataset. Daily rainfall durations in this 30 year-long climate data were adjusted proportionally to obtain increased or decreased daily peak rainfall intensities. Using the original and adjusted climate data, runoff and soil erosion were to be simulated for 30 years. The effect of *indirect* rainfall intensity changes on runoff and erosion were then analysed.

Pros: Simple, easy and fast.

Cons: It may be considered to be crude and simple for simulating future rainfall intensity changes. It does not make a full use of the findings from the previous analyses. This clearly is an indirect approach.

9.2.2 Method Two: Changing One of CLIGEN Inputs, MX .5P

The CLIGEN *input* file was adjusted accordingly rather than the CLIGEN *output* file. Two CLIGEN input files were prepared as if they are from two different periods—present and future—of the site. Future climate changes may be seen as "two different climate conditions in the same place with temporal variation". The original input file was built using observed event rainfall data from Ditchling Road station. Rainfall intensity parameter (MX .5P) of the original input file was adjusted accordingly to represent future rainfall intensity changes (Table 9.1). Two sets of CLIGEN generated weather data using these two input files only differ in peak rainfall intensities, which is controlled by MX .5P. Then, WEPP simulates runoff and soil loss rates using these two CLIGEN climate data.

Table 9.1 Ratio of MX .5P changes for each month

	Decrease		Increase	
Wet Season (SONDJF months)	−10%	−5%	+5%	+10%
Dry Season (MAMJJA months)	−10%	−5%	+5%	+10%

Few studies pointed out that the ratio of wet and dry days will influence the behaviour of future soil erosion (Nearing, 2001; Pruski and Nearing, 2002*a*,*b*). However, as this thesis only concentrates on the implication of rainfall intensity changes, no rainfall frequency change is considered. No rainfall amount change is also assumed here. Due to the lack of information, no intra-storm rainfall intensity pattern for the future was considered.

As Nearing pointed out (personal e-mail communications, 8 June 2001), if MEAN P in CLIGEN input file is changed together with MX .5P, we would end up with completely different climate data from what we have started with. Also, generated data may not have clear relationships with original data. This is a problem for a sensitivity-type comparison—that is, comparing how WEPP estimates differ for two well-defined sets of input data. On the other hand, when creating "realistic" future rainfall data is to be the main concern, both parameters (MEAN P and MX .5P), together with other parameters may need to be changed. It will, however, only be applicable to the case where sufficient reference data are available for the adjustment and comparison of all the parameter. No such information has been available for this research. Therefore, when such method is used, it is important to limit the changes only to MX .5P, and carry out the sensitivity-type comparison.

It is very unlikely all the month will have the same changes in rainfall intensity. There will be some degrees of variations depending on seasons, for example. Two seasonal variations are considered here—Wet and Dry season. The wet season includes September, October, November, December, January and February (Table 9.2). The dry season consists of March, April, May, June, July and August (Table 9.3).

Table 9.2 Adjusted MX .5P values for the wet season

month	**1**	**2**	3	4	5	6	7	8	**9**	**10**	**11**	**12**
−10%	0.24	0.16	0.23	0.23	0.27	0.33	0.42	0.58	0.39	0.41	0.31	0.27
−5%	0.26	0.17	0.23	0.23	0.27	0.33	0.42	0.58	0.41	0.43	0.32	0.28
original	0.27	0.18	0.23	0.23	0.27	0.33	0.42	0.58	0.43	0.45	0.34	0.30
5%	0.28	0.19	0.23	0.23	0.27	0.33	0.42	0.58	0.45	0.47	0.36	0.32
10%	0.30	0.20	0.23	0.23	0.27	0.33	0.42	0.58	0.47	0.50	0.37	0.33

Since soil erosion is closely related to the extreme rainfall events, this thesis concentrates on extreme rainfall events which are closely related to the rainfall parameter, MX .5P. This is the main reason why MX .5P is chosen to be altered. It is clear that Nicks

Table 9.3 Adjusted MX .5P values for the dry season

month	1	2	3	4	5	6	7	8	9	10	11	12
−10%	0.27	0.18	0.21	0.21	0.24	0.30	0.38	0.52	0.43	0.45	0.34	0.30
−5%	0.27	0.18	0.22	0.22	0.26	0.31	0.40	0.55	0.43	0.45	0.34	0.30
original	0.27	0.18	0.23	0.23	0.27	0.33	0.42	0.58	0.43	0.45	0.34	0.30
5%	0.27	0.18	0.24	0.24	0.28	0.35	0.44	0.61	0.43	0.45	0.34	0.30
10%	0.27	0.18	0.25	0.25	0.30	0.36	0.46	0.64	0.43	0.45	0.34	0.30

et al. (1995) has recognised the close statistical relationship between MX .5P and soil erosion rate. This may explain why this parameter is included in a CLIGEN input file.

Pros: It might be a new approach to the changes of future rainfall intensity. The procedures are relatively easy and uncomplicated. Calculating MX .5P is relatively straightforward from tipping-bucket data. It does change the rainfall intensity of extreme events. By adjusting monthly values, seasonal variations can be considered. It may be possible to calculate annual trend of MX .5P.

Cons: Generated rainfall data for the original and "future" climate are almost the same except rainfall intensity. Assumed future condition here is not the most likely future climate condition. Future climate will change in complex ways, not only extreme rainfall intensity will change, but also probabilities of raindays, inter-storm patterns, and, surly rainfall amount will change. Also, even if we increase or decrease extreme rainfall intensity only, the intensity of small rainfall events are also affected in order to keep overall annual rainfall amount constant.

Description of MX .5P (Yu, personal communication 2003) MX .5P is defined as "Average maximum 30-min peak intensity (in/hr) for each month". If the sub-daily interval is denoted as Δt (min), then there are $1440/\Delta t$ intervals, called M_t, in a day. For each wet day, discard all the dry intervals to create a single storm event with *continuous* rain for, say, M intervals. Then the storm duration, D, (min) is given by:

$$D = M\Delta t\delta \tag{9.1}$$

Find the maximum precipitation intensity for any 30-min period within the storm, and call this I_{30}. If there are n wet days in a month, find the maximum of these n I_{30} values, and denote this maximum I_{30} for the month as $maxI_{30}$. If there are K months on record, then MX .5P is given by:

$$MX\ .5P = \frac{1}{K}\sum maxI_{30} \tag{9.2}$$

For example, let us say it rained on 3rd and 10th of May, 2001 with a peak 30-min intensity of 1.2 in/hr and 1.5 in/hr, respectively. Then $maxI_{30}$ would be 1.5 in/hr for May 2001. If we have 5 years of data for May:

Month	Year	$maxI_{30}$ (in/hr)
May	1997	0.8
May	1998	0.9
May	1999	0.3
May	2000	2.8
May	2001	1.5

Then the MX .5P value for May for this hypothetical site would be:

$$\frac{0.8 + 0.9 + 0.3 + 2.8 + 1.5}{5} = 1.26 \text{ (in/hr)}. \tag{9.3}$$

9.2.3 Method Three: Using GCM/RCM Data

This third method described here was proposed originally, but has not been used because there were no GCM data which were suitable for this research because of the scale mismatch. Nevertheless, daily RCM data for current and future climate have been acquired. RCM also produced 20-min rainfall data, but with a high variability. Daily rainfall intensity (or amount) is not suitable to be used as erosion model input directly unless downscaled.

The procedures of this method are:

1. GCM data with 30-min time step for current and future climate
2. CLIGEN input files for current and future climate are built
3. CLIGEN generates climate data for current and future climate
4. WEPP simulates runoff and erosion for current and future climate.

It might be possible to calculate all the CLIGEN input parameters out of the GCM output. GCMs can generate current and future climate data on a sufficient time scale—that is, 30-min time step—for building CLIGEN input files. This will permit ones to make a "better" (or maybe worse) judgement of impacts of rainfall intensity changes on future soil erosion.

There are some possible caveats with this approach. One is that high resolution climate data such as highly specified GCM and RCM data are generated with the most extreme set-ups of the climate model. This will push the model to its limitation. These generated data, thus, may have problems and errors caused by unconventional configurations on the top of GCMs' uncertainty and wide range of variations. Another caveat is that the high resolution data are not always readily available. A separate model configuration is required to generate this kind of data, and the set-up process involving usually requires extended model set-up skills and simulation times. This was the case for the current research. Another possible problem is that, because of the preceding uncertainty of GCM output, we might end up with erroneous CLIGEN input files which, in turn, will lead to even greater errors for future erosion estimation.

9.2.4 Selected Method: Method Two, Changing CLIGEN Input

The Method Two (Section 9.2.2) is selected. The schematic procedure of this method is shown in Figure 9.1.

It was assumed that future WSIV, WSP and WSIP are the same as the present. Only monthly maximum of 30-min peak rainfall intensity was considered for constructing future rainfall intensity scenarios.

CLIGEN generates original climate data using the input file which statistically represents the characteristics of current rainfall intensity. Keeping all other parameters constant, the intensity parameter (MX .5P) in the CLIGEN input file are increased or decreased proportionally (Table 9.1). MX .5P is specifically related to extreme intensity events as given by its definition, 'Average maximum 30 minutes peak intensity (in/hr) for each month'. "Future" climate data are then generated using adjusted CLIGEN input file. WEPP simulates runoff and soil loss using both climate data. Runoff and soil loss changes are compared with changes in rainfall intensity.

9.3 Sensitivity of WEPP to Rainfall Intensity Changes

Before using WEPP for the current investigation, the sensitivity of WEPP to changes in rainfall intensity were tested. Rainfall intensity was modified indirectly by controlling the rainfall duration. The rainfall amount and ratio of average intensity to peak intensity were not changed. The relationship between actual peak intensity, I and rainfall duration, D can be described as:

$$I = i_p \times \frac{R}{D} \tag{9.4}$$

where i_p is normalised peak intensity, R is rainfall amount.

The rainfall amount, R, and normalised peak intensity, i_p, are parametrised in a

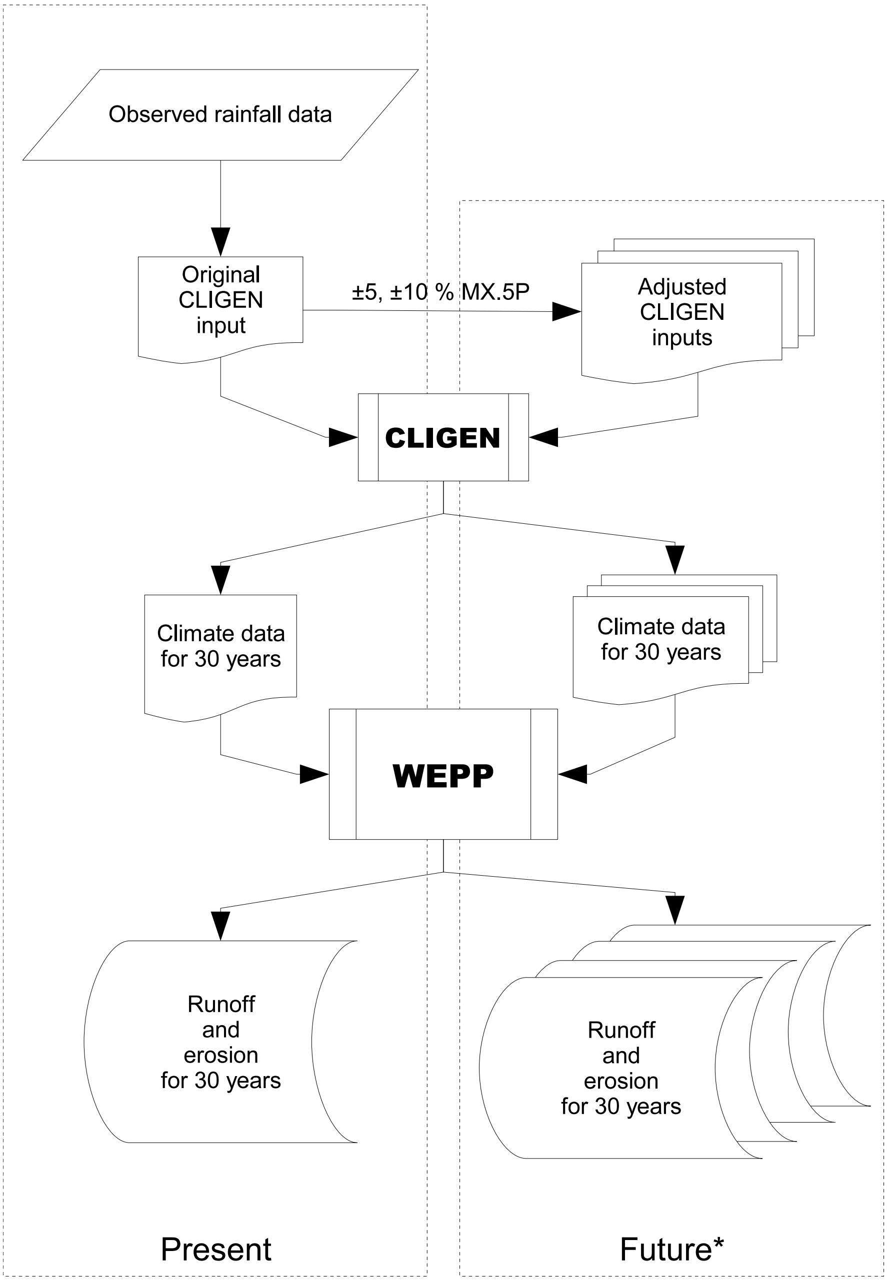


Figure 9.1 Schematic flowchart of the method which is used for investigation of implications of rainfall intensity changes for future soil erosion. Soil erosion simulated in the left-side box marked with 'Present' represents the present erosion rate under current rainfall intensity. Soil erosion simulated in the right-side box marked with 'Future*' represents assumed future erosion rates under the different rainfall intensities.

CLIGEN input file as station specific parameters (i.e. MEAN P and MX .5P), so that they should not be changed directly from a CLIGEN output file. On the other hand, rainfall duration, D, is generated by CLIGEN in relation to R and i_p values. Thus, *only* daily peak rainfall intensities are increased or decreased by decreasing or increasing rainfall duration while keeping the rainfall amount constant (Table 9.4). All other factors, such as rainfall frequency and seasonal intensity variation, are unchanged.

Table 9.4 Peak rainfall intensity changes (%) for WEPP simulation

Duration	142.9	125.0	111.1	100	90.9	83.3	76.9
Peak Intensity	70	80	90	100	110	120	130

Runoff and soil loss amount were estimated by WEPP (v2004.7). CLIGEN (v5.2) was used to generate weather data using updated Ditchling Road input (see Appendix B.2). Calibrated WEPP was used as previously reported. The resulting annual runoff and soil loss rate were analysed to find out whether WEPP is sensitive to rainfall intensity changes.

9.3.1 Runoff and Soil Loss

The mean annual soil loss estimated by WEPP increases or decreases as peak intensity increases or decreases (Figure 9.2). WEPP is sensitive to daily peak intensity changes with the rate of $\beta = 1.46$ ($y = \alpha + \beta x$). This means that for each 1% increase or decrease in daily peak intensity, WEPP estimates a 1.46% increase or decrease in the annual soil loss. The annual runoff rate is slightly less sensitive to the changes in peak rainfall intensity than annual soil loss 9.2.

9.3.2 Discussion

As the result implies, WEPP is sensitive to a change in rainfall intensity.

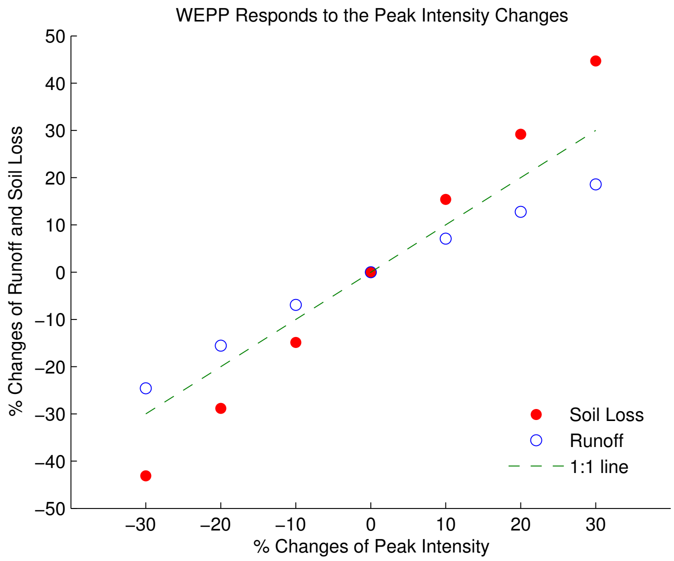


Figure 9.2 WEPP responses to the peak rainfall intensity changes

Although the method used here is arguably simple and crude, it serves the aim of this study. It clearly shows the sensitivity of WEPP to rainfall intensity changes. However, the resultant change in rates of soil loss in response to the daily peak rainfall intensity is rather difficult to accept.

This is due to the following reasons:

- This is an indirect approach to changing rainfall intensity.
- The normalised daily peak intensity parameter, i_p, has not been changed. Thus, the relative magnitude of daily peak intensity to the daily average intensity is the same.
- No seasonal variation is considered as every rainfall duration is perturbed with the same change rate.

Moreover, when the same changes were applied to daily rainfall durations across the data period, some of the events became extended over 24 hour period. These events however were forced to be 24 hour events. This, however, did not affect the final results.

WEPP may be used for the investigation, *Estimation of Future Soil Erosion*. However, it is important to keep in mind the limitations discussed previously (see Section 7.7).

9.4 Estimation of Future Soil Erosion

As pointed out previously, our ability to predict future soil erosion is largely limited by the shortcomings of GCMs. At the time of writing, magnitudes of future rainfall intensity changes are not yet clearly quantified. Nevertheless, it is evident that the observed frequency of heavy rainfall has increased in the region of 2–4% over the latter half of the 20th century (IPCC Working Group I, 2001).

However, this still does not provide sufficient detail in rainfall information required by the soil erosion models used here. In this research, it has been shown that temporal scales of rainfall data, intra-storm intensity pattern and continuity of rainfall duration affect soil erosion, and it is necessary to know these information in order to estimate soil erosion adequately. The effect of these factors on soil erosion are discussed previously (Chapter 5, Chapter 7 and Chapter 6).

In order to investigate the impacts of future rainfall intensity changes on soil erosion, it is undoubtedly necessary to know what future rainfall intensity is like, and then apply these rainfall intensity changes to soil erosion models to estimate the future soil erosion rate. However, this seems rather problematic as pointed out previously. Also, the changes in rainfall intensity are geographically dependent, and thus is soil erosion.

Therefore, the important question is “What may change in relation to rainfall characteristics?” The following are expected to change:

- rainfall amount
- rainfall intensity
- rainfall (intensity) pattern

- number of wet and dry days (or ratio of wet/dry days)

In the future, we may experience a mixture of all these factors. However, with current technology for climate predictions, it is very difficult to quantify the changes in future rainfall characteristics with precise figures. In terms of rainfall intensity, it has been possible to speculate future rainfall intensity by looking at direct and indirect factors related to the rainfall intensity:

- Increased atmospheric moisture contents may lead to more frequent heavy rainfall events;
- Increased atmospheric water-holding capacity may lead to fewer raindays;
- Slight increase or almost no changes in future average rainfall amount.

The last point is a site specific factor for the research site considered in this thesis. By analysing observed daily rainfall amount data from the research site, South Downs, UK, it is evident that there is an increasing trend in daily rainfall intensity (i.e. SDII) with seasonal variabilities.

9.4.1 Estimated Future Rainfall for WEPP Simulations

A number of rainfall events generated by CLIGEN for all conditions are exactly the same. The number of raindays is about 151 days per year on average. The total annual rainfall amounts for all conditions are also the same (Figure 9.3).

The changes in mean maximum 30-min peak intensity shows negative relationships, as expected, with the rainfall duration changes. Every 1% decrease/increase in mean maximum 30-min peak intensity of wet seasons results in a 0.75% increase/decrease in annual rainfall duration (Figure 9.4). For the changes in dry season, the magnitude of

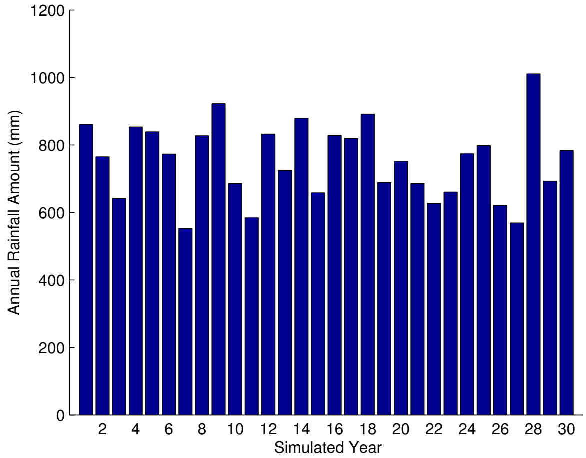


Figure 9.3 Simulated annual rainfall amount using CLIGEN

the change was more gradual than that of the wet season (Figure 9.4). Every 1% change in the peak intensity of dry season caused a −0.45% change in annual rainfall duration 9.4.

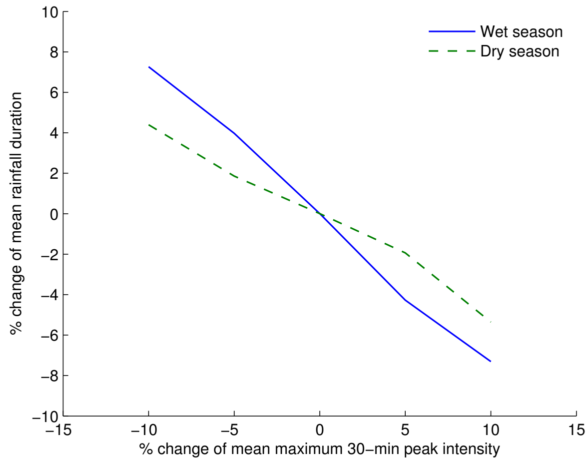
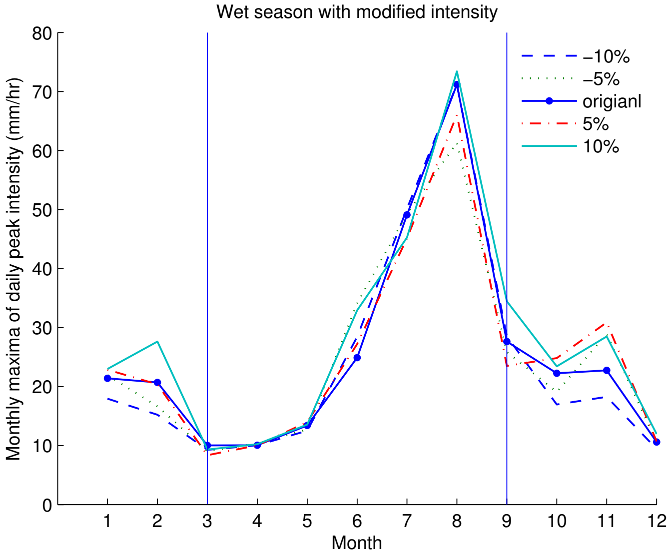
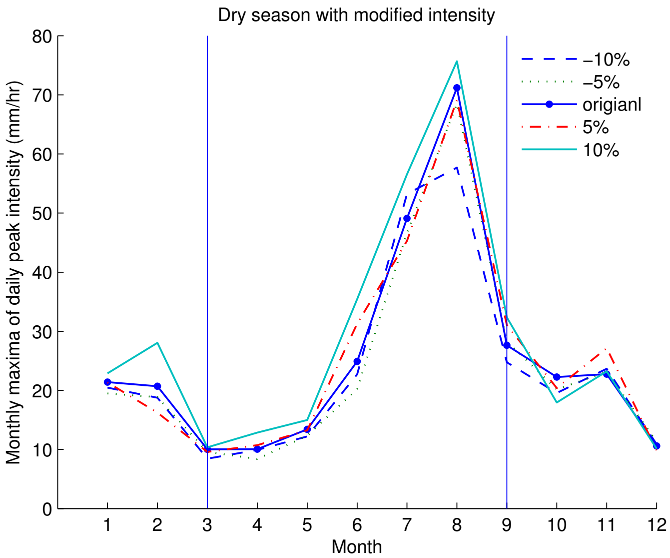


Figure 9.4 Simulated annual rainfall duration changes by changing mean maximum 30-min peak intensity for wet and dry seasons.

The changes in average monthly maxima of daily peak intensity for wet and dry season affected CLIGEN simulated daily peak rainfall intensities (Figure 9.5). The changes in average monthly maxima of daily peak intensity in the wet season resulted in increased or decreased daily peak intensities for wet months (SONDJF). This was also the case for the dry months (MAMJJA).



(a) Wet months (9, 10, 11, 12, 1, 2) with modified intensity



(b) Dry months (3, 4, 5, 6, 7, 8) with modified intensity

Figure 9.5 Monthly maxima of daily peak rainfall intensity changes generated by CLIGEN with modified mean maximum 30-min peak intensity

9.4.2 Estimated Changes of Future Soil Erosion

For the wet season, increases or decreases in mean maximum 30-min peak intensity generally yield increases or decreases in runoff. Every 1% change in the mean maximum 30-min peak intensity for the wet months (SONDJF) resulted in about a 0.72% change in the mean annual runoff (Figure 9.6). For the dry season, 5% change in mean maximum 30-min peak intensity yield the greatest changes in runoff (Figure 9.6) compared to 10% changes in the intensity. When mean maximum 30-min peak intensity increases ten per cent, runoff increases, but increases less than that of 5% change in the intensity. The similar effect is observed for 10% decrease in the intensity.

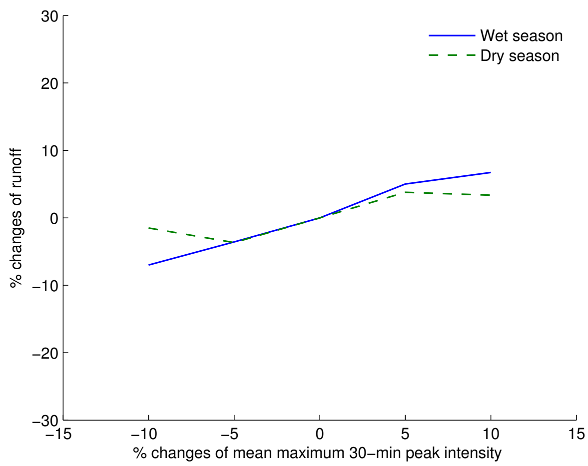


Figure 9.6 Runoff changes in response to the changes of mean maximum 30-min peak intensity for wet and dry seasons.

The effect of mean maximum 30-min peak intensity changes on soil loss changes are more distinctive than on runoff. The effect of the intensity changes in the wet season and the dry season are markedly different (Figure 9.7). For the wet season, every 1% increase or decrease in mean maximum 30-min peak intensity resulted in about a 2% increase or decrease in mean annual soil loss rates (Figure 9.7).

The change in mean maximum 30-min peak intensity for dry months show no

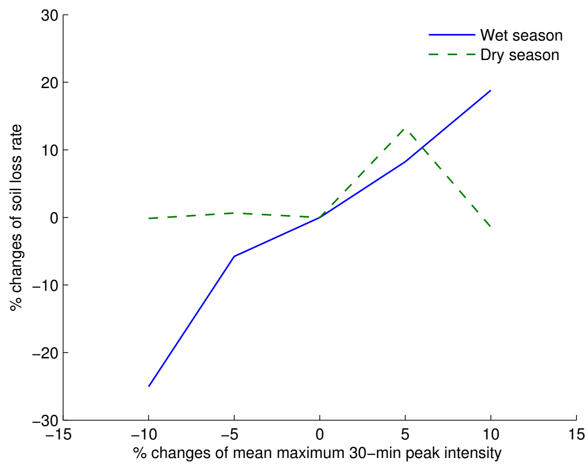


Figure 9.7 Soil loss rate changes in response to the changes of mean maximum 30-min peak intensity for wet and dry seasons.

significant effect on soil loss rates except a 5% increase in the intensity (Figure 9.7). When mean maximum 30-min peak intensity is 5% increased, average annual soil loss rate increase about a 13.3% in the dry season (Figure 9.7). This is a 2.7% increase in soil loss rate per every 1% increase in the intensity. This rate of change is greater than the magnitude of the effect of the intensity changes in the wet season (i.e. a 2% change in soil loss per every 1% change in the intensity).

9.4.3 Discussion

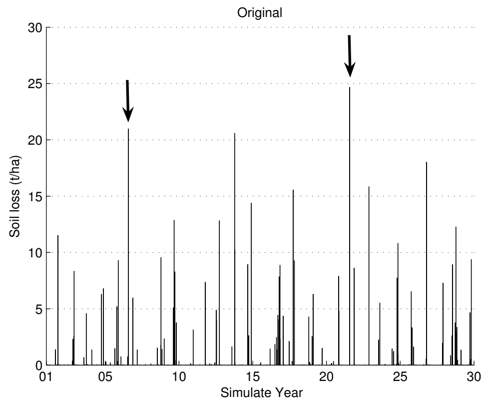
The exceptional response of soil loss rate changes to the 5% increase in mean maximum 30-min peak intensity in the dry season are investigated by looking into event by event simulation results. The 5% increase in the intensity increases the number of storm runoff incidents than with original intensity. However, amount of runoff generated by 5% increased intensity is slightly (i.e. 4%) greater than that of the original intensity (mean runoff amount generated per event is 74.8 mm). This means that each 1% increase in the intensity resulted in a 0.8% increase in runoff. Despite this small differences in runoff amounts, soil loss rates are 13% increased in response to 5% increase in the intensity in the dry season.

By looking at the number of events which yield soil loss rates more than 15 t/ha, there are 6, 10 and 8 events for the original intensity, 5% increased intensity and 10% increased intensity, respectively (Figure 9.8). There are evidently more incidents of large erosion events for 5% increased intensity. However, the differences in number of erosion event over 15 t/ha are not the result of intensity changes in the dry season. By looking at the date of each events, far from two events on 29 July in year 6 and in year 21, all other events occurred in the wet season, mostly in September, October and November. Also, 29 July is the same date as the harvest date used for WEPP management input (Table 3.5).

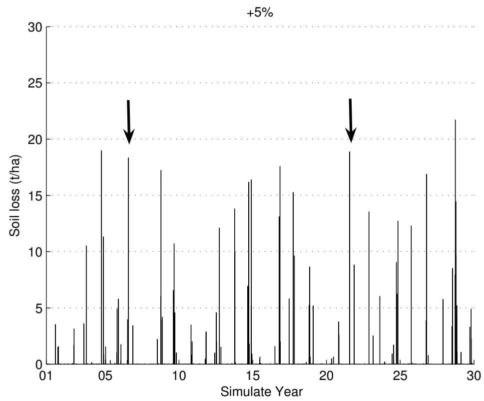
The intensity increase in dry months is not significantly effective to cause erosion rate as either they do not have sufficient rainfall amounts to initiate erosion or surface conditions are not susceptible for erosion because of sufficient crop covers. The rainfall intensity becomes more important where other factors such as rainfall amounts are enough to initiate soil erosion. Thus, intensity increases in the dry months are not effective as intensity increases in the wet months where rainfall amounts are greater.

The effect of an increase or decrease in monthly mean maximum 30-min peak intensity in the wet months (SONDJF) are not constrained only to the wet months, but also slightly to other months—i.e. the dry months (MAMJJA) decreasing or increasing the peak intensity (Figure 9.5a). A similar effect is also observed when monthly mean maximum 30-min peak intensity in the dry months are changed (Figure 9.5b). This may be due to the fact that CLIGEN attempts to keep the overall rainfall amount close to the original value.

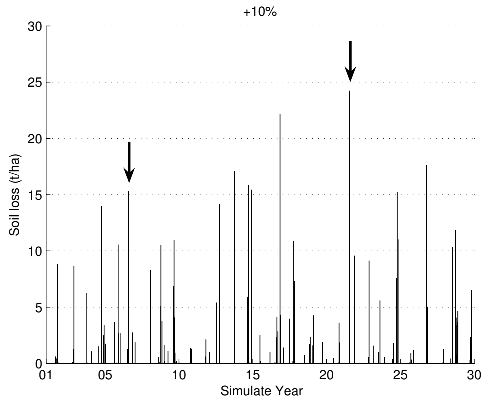
Each percent change in a peak intensity of extreme events during the wet season may result in double percent changes in soil loss rates. This is partly due to WEPP estimates a gradual increase in runoff amount while the number of runoff events is reduced. As



(a) Original



(b) +5%



(c) +10%

Figure 9.8 Effects of 5% and 10% increases of mean maximum 30-min peak intensity on WEPP generated soil loss rates (t/ha) for individual events. The arrows indicate the erosion events with >15 t/ha soil loss on 29 July of year 6 and year 21.

a result of an increased peak intensity during the wet season, less rainfall events were simulated to retain overall rainfall amount and number of raindays.

The WEPP simulation results in this chapter suggest that every 1% increase or decrease in the mean maximum 30-min peak intensity in the wet season (September to February) resulted in a 0.72% increase or decrease in mean annual runoff, and a 2% increase or decrease in mean annual soil loss rate.

We do not know precisely what the future rainfall intensity would be like. Even with climate change models, it is difficult to predict all the rainfall information required by the present-day erosion models. Without knowing these rainfall intensity, estimation of future erosion can go wrong easily as shown previously. However, using perturbed extreme rainfall intensity will provide a clear and robust comparisons of soil erosion rates under the conditions where the extreme rainfall intensity is expected to be increased or decreased.

Despite the availability of various methods we take to predict future rainfall intensity, predicting soil erosion with good confidence level is almost impossible (may not be viable) at the moment because the uncertainty involved for the prediction is too great to be meaningful. As shown in this research, even with slight different rainfall intensity from the true value—which we may not be able to know truly—will result in completely different soil erosion results. However, it is true to say that increased rainfall which may mean—not necessarily always though—increased erosive power of rainfall and this increase will result in increased erosion rates.

9.5 Conclusion

This chapter aimed to find out the impact of rainfall intensity changes on future soil erosion by looking at the effect of increased and decreased extreme rainfall intensity. Two seasonal variations were considered—the wet and dry season.

The method employed in this chapter successfully generated two different climate datasets with perturbed monthly rainfall intensity without affecting rainfall amount and frequency of rainfall. It is important to acquire such dataset in order to investigate effect of rainfall intensity without compound effects from other rainfall factors such as amount and frequency of rainfall.

The WEPP simulation results in this chapter suggest that, where the mean maximum 30-min peak intensity in the wet months increases, runoff and soil erosion increase. Particularly the amount of erosion increases at a even greater rate than the amount of runoff. The ratio of erosion increases to the rainfall intensity increase is on the order of 2.

All the figures of simulation outputs from this stage should not be accepted as "true" values without careful interpretations. They do not have an adequate certainty to be accepted directly. It should also be noted that high levels of uncertainty may be present in the result of the simulation.