Chapter 2. Description of the study area and its flooding problems

to two reasons: first, they have more discharge capacity and second, their recharge areas are located in the upper Turrialba Basin while the rainfalls occur mostly in the lower and middle parts. The Turrialba River can deal with peak discharges with a return period of 100 years without overflowing (Solís et al., 1993).

Another important problem in the area is the riverbank erosion mainly along the Turrialba and Colorado rivers. Both situations (flooding and erosion) represent large economical losses because of damages to infrastructure and residential areas. The erosion of riverbanks also represents an increase of the possibilities of overflowing in certain points. To understand these phenomena is necessary to know their causes and in this way, it is easier to develop plans to mitigate the events and the damages caused by them.

The flooding problem in Turrialba has not only natural causes, but they are also due to factors related to the location of population settlements and their behaviour. At least, three different types of flood causes have been identified for the study area: meteorological, geomorphological and urban factors. The precipitation is considered by Aparicio (1999) as the principal flood cause in Turrialba, together with the urban expansion in hazardous areas.

2.3.1 Meteorological causes

The climate in the Turrialba Basin is very complex because it is influenced by micro-climatic variables. The meteorological conditions in the area induce torrential rainfalls caused by humid winds coming from the Caribbean Sea through the Reventazón River’s valley (Calvo, 1993). Once the winds reach the Turrialba Basin, they can follow two different ways: they can go to the northern part of the basin or continue a bit more through the Reventazón River and enter the Turrialba Basin by its south part.

If the winds go to the north, it rains mostly on the area of Aquiares and surroundings. In this case, the runoff drains straight to the Turrialba River, causing peak discharges in this river. If the humidity enters through the south, the precipitation takes place especially in the Colorado Basin. Therefore, peak discharges can cause flooding of this river. Finally, when the air masses are big enough, the extreme rainfalls may reach even the upper part of the Turrialba Basin, producing not moderate events, as in the previous cases, but catastrophic events (García, 1990).

The discharges of the Turrialba and Colorado rivers tend to behave according to this pluviometrical regime ruled by micro-climatic factors. These discharges are characterised by very low averages, but with occasional extremely high peaks (García, 1990). No relationship was found between flood occurrence in Turrialba and regional meteorological events such as large tropical storms, hurricanes and tropical depressions (Aparicio, 1999).

As it is going to be explained in detail in Section 3.2, December is the most hazardous month of the year for Turrialba City. It is because December is the month with the highest total monthly precipitation, with maximum peak discharges and also when the largest number of floods have occurred (Aparicio, 1999). This situation has a meteorological explanation. During this specific
2.3. Flood problems in the city of Turrialba and their causes

Month, the cloudiness is mainly located between 1200 and 1500 metres above the sea level, corresponding with the upper Colorado Basin, and this causes an increase in the precipitation in this specific area. In addition, because of the Foehn effect, a high precipitation zone occurs between 600 and 1200 m.a.s.l., covering almost the whole Colorado Basin (García, 1990).

February, in spite of being a dry month, also sticks out for the presence of important peak discharges and high monthly precipitations and because it follows December in the occurrence of flood events (Aparicio, 1999). But in this case, no explanation has been found for this behaviour, but maybe these flash floods have been caused by isolated torrential rains or by storms with a certain intensity or direction.

2.3.2 Geomorphological causes of flooding and riverbank erosion

The location of Turrialba City at the lower part of the Turrialba Basin, has contributed to the flood problems. It is built just at the foot slopes, on top of the alluvial fan, where there is an abrupt change in the slope angle. Therefore rivers come with a very high velocity and energy from high in the mountains. The city covers a large part of the alluvial fan and the alluvial plains, and sometimes even the riverbeds (see Figure 2.5), areas that are naturally flooded during peak events of the rivers.

This situation is aggravated by the presence of very tight curves in the river channels and a very high sediment load due to landslides occurring upstream during rainfalls (Madrigal, 1996).

The lithology plays also an important role. Rivers that cause floods come from mountains formed by very weathered lavas. These lavas are covered by a thick layer of clayey soils, which are very impervious. For this reason, infiltration in these mountains is quite reduced and an important amount of rainfall is drained downslope through small watercourses.

In relation to the problem of riverbank erosion, geomorphology plays also a role. Turrialba River has a very dynamic channel that suffers frequent vertical and horizontal changes. It happens according to its necessity of adapting its equilibrium profile to the hydrologic conditions of the basin. The most problematic and dangerous sector of the river is where it crosses the city. The horizontal changes are related to the variations of the river bends and the vertical ones consider changes in micro relief of the riverbed. So, it can be said that there is an interesting relationship between morphology of the riverbed and behaviour of the river during the peak events (García, 1990).

2.3.3 Urban expansion and landuse change and their relation with the flooding problem

Turrialba City has experienced a large population growth in the last decades. This situation, combined with wrong policies in urban and landuse planning, has intensified the flood problems in the study area.
In 1918, the District of Turrialba had a population of 5391 inhabitants (Aparicio, 1999), while in 2000 it had 32004 (INEC, 2001). At the level of the Canton of Turrialba, it can be seeing that population increased from 9216 inhabitants in 1918 (Aparicio, 1999) to 68510 in 2000 (INEC, 2001). Turrialba District is now the most populated within the Canton, with 46.7% of the inhabitants.

But the problem is not only that the city has grown up, but also that the urban area has expanded to hazardous areas on the flood plains of the rivers (see Figure 2.6). In addition, the large cover of buildings and asphalt has reduced the natural high capacity of infiltration of the alluvial fan deposits to almost zero. Now, runoff water has to invade the city roads in its way to the rivers, increasing the possibility of damage to houses and infrastructure.

A comparative analysis between population growth and precipitation was carried out by Aparicio (1999). It shows that since 1949, the amount of rainfall that is necessary to cause a flood has been decreasing, in general, according to the increase in the population of Turrialba City. The only exception that can be done is the 1996 flood event, which showed the largest 2-days mean precip-
2.3. Flood problems in the city of Turrialba and their causes

Itation (see Section 3.2) in 50 years (242 mm). But is interesting to point out that only half of this precipitation would have been enough to cause a flood (the 1991 event was caused by a rainfall of 120 mm) and that in 1923 a similar precipitation was recorded, with no flood generated. The precipitation necessary to generate a flood during the first half of the 20th century was more or less 180 mm. Now, it is considered that a maximum daily precipitation of 100 mm is enough to trigger a flooding. Furthermore, an increase in the frequency of flood events was detected since 1970.

In addition, there has been a change in the landuse, from forest to grasslands or agricultural areas, especially in the upper Turrialba Basin. It has led to the increase of the peak discharges, the erosion, contamination and decrease of soil fertility.