

Chapter 4

Social and Environmental Vulnerability in a River Basin of Mexico

Úrsula Oswald Spring

Abstract Given the paralysis in global multilateral environmental negotiations and a lack of determination among the heads of states and governments of both the G8 and the G20 countries, alternative strategies, policies and measures towards a sustainability transition are proposed that actively involve civil society and the economic sector. Starting with general questions related to global environmental change, the chapter goes on to address the following questions: what are the real necessities for the Earth and for world society as a whole, especially for the socially vulnerable, and how can poor people living in a high-risk water basin and affected by climate change develop sustainable alternatives to deal with social and environmental vulnerability? A second question is how ethically committed scientists could support these bottom-up efforts to research and advise about the complex interactions existing between the natural and the human systems. The chapter first presents a conceptual argument concerning a double vulnerability. Later both environmental and social vulnerabilities are investigated in a river basin in Mexico greatly affected by climate change due to glacier melting on Popocatepetl, flash floods, droughts, urbanization, land use changes without urban planning, inadequate productive and waste management, overuse of water and social marginalization, especially for young people and the elderly. The next section deals with the description of the arena of conflict in this basin where water pollution and scarcity, land use changes related to chaotic urbanization and survival dilemmas caused by the desertification of rural areas are triggered by organized crime, pushing communities and family members towards migration.

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However, the global financial crisis, the lack of a counter-cyclical policy in the Mexican government and the migration policy of the USA have placed limits on international migration as a possible adaptation process, often bringing people to the edge of survival. This means that changes and adaptation are complex phenomena understood very differently in scientific disciplines and by the people affected.

Keywords Adaptation · Coping strategies · Disaster risk reduction · Droughts · Environmental vulnerability · Flash floods · Global environmental change · Resilience · Social vulnerability · Yautepec River Basin

4.1 Introduction

Since 2009, the *Conference of the Parties (COP)* of the *United Nations Framework Convention on Climate Change (UNFCCC)* has failed to adopt any legally binding agreement on reducing *greenhouse gas emissions (GHG)*. At Rio +20 in June 2012, no new legal obligations were approved at the three Rio conventions (UNFCCC, CBD, UNCCD) pertaining to threatened ecosystem services and the reduction of the over-exploitation of natural resources. Simultaneously, at the VIIth G20 Leaders' Summit in Los Cabos, Mexico, "the IMF's financial resources were increased to over \$450 billion USD" in order to expand the IMF's capacity to cope with the global economic crises. However, on global environmental change only verbal declarations were made on the subject of launching a "Dialogue Platform on Inclusive Green Investments" that would identify "private investment opportunities in green projects".¹ Given the paralysis of the global multilateral environmental negotiations since the economic crisis (2008) and the lack of determination among the heads of states and governments of both the G8 and G20 countries, there is an urgent need to pursue alternative strategies, policies and measures towards a transition towards sustainability by civil society and the economic sector.

To achieve this goal it is important at the global level to understand what is driving the priority given to supporting a crumbling financial system (Stiglitz 2002, 2006; Soros 2002) instead of saving the planet and creating a stable basis for the lives and livelihoods of the most vulnerable. What are the Earth's real necessities, and what are the crucial questions for world society as a whole and especially for the socially vulnerable, and how are people affected at the local level?

¹ See press release by President Calderón, Los Cabos, Mexico, 19th June 2012: "The VII G20 Leaders' Summit Concludes"; at: <http://www.g20mexico.org/index.php/en/press-releases/460-concluye-la-vii-cumbre-de-lideres-del-g20>.

Given these global questions, this chapter examines what is policy-relevant for a special region that is highly affected by *global environmental change*² (GEC). The aim is to reduce the risks faced by those people who are most threatened by both environmental and social vulnerability. This chapter addresses the research question of how poor people who are living in a high-risk river basin in Mexico and who are affected by (GEC) can develop coping strategies to overcome both social and environmental vulnerability.

The chapter is divided into six parts. After this introduction the next part introduces the concept of environmental and social vulnerability (Sect. 4.2), the research area and the research methodology (Sect. 4.3). Then both vulnerabilities are investigated in the Yautepec River Basin (Sect. 4.4) in Mexico, a region highly affected by GEC due to human activities. To cope with these environmental and social challenges people are developing bottom-up and top-down strategies (Sect. 4.5), while the conclusions offer a proposal for sustainable management of this high-risk river basin from a gender perspective (Sect. 4.6).

4.2 Environmental and Social Vulnerability: A Double Vulnerability

This chapter uses the concept of double vulnerability as an analytical tool for empirical analysis and assessment (Fig. 4.1). *Environmental vulnerability* is related to pollution and water shortages aggravated by climate variability where rapid-onset extreme hydrometeorological events (flash floods, cyclones) and medium-term (drought, erosion) and long-term (desertification) processes aggravate fragile soil conditions in areas of steep slopes and stony and shallow layers with a superficial horizon of fertility.

Regarding *social vulnerability*, pressures are caused by globalization impact on a social environment characterized by poverty, insecurity, gender discrimination, hunger, obesity, disease and lack of resources. This double pressure is aggravated

² *Global environmental change* (GEC) is more than climate change. GEC includes the interaction between natural and anthropogenic factors. GEC is caused by human beings using anthropogenic nitrogen for crop fertilization and toxic pesticides, lixiviated and percolated into rivers, soil, aquifers and seas. The intensive use of fossil carbon has altered the chemical composition of the atmosphere and the climate with an anthropogenic increase in temperature; change of precipitation patterns; melting of glaciers, permafrost, Arctic and Antarctic ice shields; sea level rise; stronger cyclones and longer and more intensive droughts; and more intense extreme weather events affecting humans, productive processes and infrastructure. But in addition regressive globalization (Held/McGrew 2007), the financial crisis, and a high concentration of wealth in a few hands through speculation and financial management (Stiglitz 2002) have increased poverty and hunger, and these have been aggravated by high population growth. Finally, unsustainable productive processes with GHG emissions and waste of natural resources have increased the pollution of air, soil and water, directly affecting biodiversity and ecosystem services. For this reason, in the text we refer to GEC as including CC.

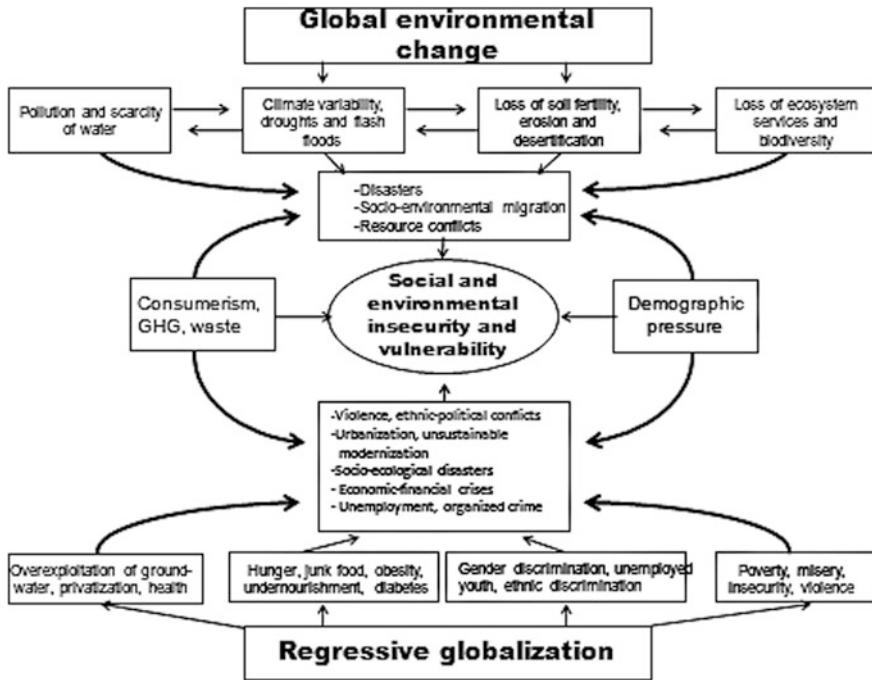


Fig. 4.1 Double environmental and social vulnerability. *Source* Oswald Spring, adapted from Bohle (2002)

by demographic growth and a wasteful consumerism where natural and social factors interlink, creating disasters, migration, resource conflicts, unemployment and violence that threaten human, gender and environmental security (HUGE; Oswald Spring 2008, 2009).

4.3 Research Area and Methodology

4.3.1 Research Area

The research focuses on a river basin in the central part of Mexico (Fig. 4.2) and covers four municipalities in the state of Mexico, nine in Morelos, and a small mountain part of Mexico City. The *Yautepec River Basin* (YRB) originates on the glacier of Popocatepetl (5,452 m) in the state of Mexico and receives dozens of tributaries and springs from the neovolcanic axis. Popocatepetl limits the watershed towards the east and Chichinautzin (3,476 m) the western part of the basin of the metropolitan valley of Mexico City. A third watershed running from the Tepozteco National Park, together with dozens of small intermittent tributaries,



Fig. 4.2 Location of the research area. *Source* The author

converges in the flood plain of Yautepec. All these rivers recharge the aquifer of the YRB, creating the *metropolitan zone of Cuautla* (MZC), which is the second largest economic zone in the state of Morelos. The whole basin covers an area of 1,249 km² with a population of almost 300,000 in 2013.

The two majestic volcanoes of Popocatepetl and Chichinautzin belong to the forest ecosystems of pine and oak, while the southern region is covered with tropical dry forest, stretching from the lower part of the volcanoes (Tepoztlan) to the Sierra Madre del Sur. The central valley in between has deep fertile soils produced by the erosion of volcanic sediments. In both ecosystems large areas have been protected because of their exceptional biodiversity (Fig. 4.3). Between these volcanoes, mountains and hills is the central valley. For more than a 1,000 years indigenous communities (Xochimilcas and Tlahuicas) have developed irrigation agriculture producing corn, cotton, chillies, beans, tomatoes and other important food crops and fruits (Maldonado Jiménez 1990; Mentz 2008). They produced several harvests a year because of the favourable climate and the monsoon.

After the Spaniards occupied this land they transformed this fertile valley into sugar cane plantations, taking away the irrigated land from the indigenous people. Expulsion from the fertile land, the over-exploitation of indigenous communities by the conquerors, and the creation of a monopolist hacienda structure of sugar cane industries meant that this region was actively involved both in the struggle for independence (1810–1812) and in the revolution (1910–1920). Emiliano Zapata, the leading general of the south, was born and killed in this sugar cane region. Future tendencies to population growth are estimated to be located basically in the metropolitan area of Cuernavaca and in the high plateau of the northern part of the YRB (Fig. 4.4; Partida Bush 2007; Aguilar et al. 2000).

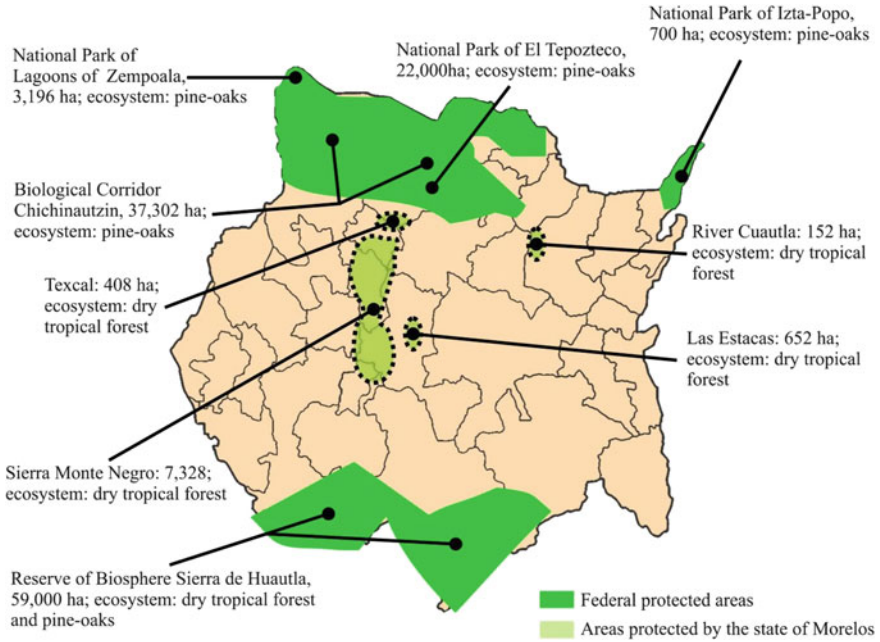


Fig. 4.3 National parks protected by the federal and state governments. Source The author

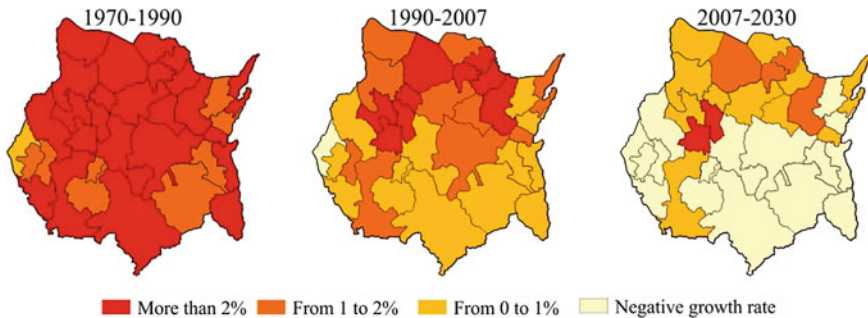


Fig. 4.4 Rate of population growth and urbanization for different periods in the state of Morelos in Mexico. Source Partida Bush (2007, p. 17)

4.3.2 Research Methodology

The research used both quantitative and qualitative methods. The quantitative approach includes databanks of official statistics, maps, satellite images and a survey that involved 3,955 people representing 1,019 households (Table 4.1). The survey is a random sample and is representative of the dynamic in the whole basin.

Table 4.1 Sample of the survey in the Yautepec River Basin

Phases of survey	People	Families	Women as %
First phase	1,440	385	49
Second phase	2,515	634	51
Total	3,955	1,019	50

Source Survey conducted by CRIM–UNAM (2010–2012)

It was undertaken between March 2010 and April 2011. During this period and in 2012 different qualitative field methods were applied in subregional settings taking urban and rural differences into account.

The qualitative methodologies facilitated the interpretation of the research results with deep-level interviews involving local leaders, politicians and key persons in the communities within the basin, anthropological participative observation, focus group discussions, a participatory rural survey, and analyses of local social movements. Regional studies compared the adaptation processes and resilience-building of different communities facing similar environmental and social threats. The research was divided into three phases over 3 years. (a) In the first year the research team carried out bibliographic studies and examined statistical series of production and demographic data, monographs and regional or local diagnoses related to the research questions. This phase included official databanks as well as local, state, national and international databanks concerning ecosystems and their transformation. These data were systematized in maps and complemented by aerial photographs, satellite images and field trips. A permanent seminar with the participants of the project integrated the different methodologies and clarified the research objectives. (b) In the second year a survey was conducted with closed and some semi-open questions, together with qualitative interviews with key informants and the recording of the life histories of families with migrants. In this phase we also analysed the transformation of the territory and the natural conditions (water, soil quality, erosion, biodiversity loss, land use change, ecological reserves) and public and private investment in the basin. Urban, environmental, agricultural, educational, and public health policies supplemented these data. In-depth interviews were conducted with political, industrial, religious and water authorities. (c) In the third year, special studies of the physical deterioration of the land, local urban planning and agricultural pilot projects were conducted and changes in the epidemiological profiles were mapped. Using focus groups, the productive coping strategies of small rural farmers, feminization of agricultural production, migration processes, transformation of crops and economic strategies to cope with lack of water, together with social participation in public activities and symbolic representations, were investigated. Local workshops promoted organic farming practices among the affected farmers. The information was included in a general map which visualized the vulnerability and socio-environmental complexity of the region and which has helped to mobilize people in the Yautepec River Basin to improve their resilience.

4.4 Double Vulnerability in the Yautepec River Basin: Disasters, Threats, Marginalization and Poverty

4.4.1 Environmental Vulnerability

The geological conditions of this river basin are related to the high volcanoes where extreme events are triggered by GEC, marginalization, institutional discrimination (Oswald Spring 2011b), and poverty. GEC is seriously affecting this river basin due to the melting of glaciers,³ the variability of precipitation, a later monsoon with altered interstitial drought periods⁴ (Taboada Salgado 2005), deforestation, and increasing population. Conagua, the national water commission of Mexico, has also noted a reduction of average rainfall by 8 % during the last two decades, along with more flash floods. Together with longer dry periods the alteration in climate is affecting the fragile ecosystem of the dry tropical forest and its biodiversity, which all depend on a regular monsoon. Small farmers living from rain-fed agriculture need to be able to predict the monsoon in order to produce their subsistence crops.

Particular attention was given to the increasing frequency and intensity of flash floods in the basin. The first important flood, with 13 casualties, occurred on 25 August 1985 and caught the population totally unprepared. Even the oldest people could not remember a similarly intensive event in their lifetime. The next major disaster occurred during a Niño year on 28 September 1998. It was then that people took note of the danger posed by the river for the growing urban population and its economic activities. The next flood was in September 2003, then on 17 August 2010, and the most serious flood took place on 25 August 2010.⁵ Since 2010, there has been at least one flash flood each year, together with longer dry periods, which have affected water availability and reduced the harvest of sugar cane and of other commercial and subsistence crops.

There are not only water-related disasters, but also water-borne illnesses. In 1992 the whole region, especially the town of Cuautla, was affected by a cholera epidemic when sewage water polluted the drinking water pipes. The emergency was only brought under control after several weeks with dozens of fatalities and thousands of sick people. Cysticercosis is endemic in the region. The increase of temperature and the use of plastic have also increased dengue fever, and the rate of dengue among people in the basin rose from 2005 to 2012 by more than 600 %,

³ The glacier is further affected by periodic explosions and expulsion of incandescent pyroclastic materials from the dome of the active Popocatepetl.

⁴ Also called midsummer drought, this phenomenon normally occurs during 2 weeks in mid-August and permits the corn plant to develop cobs. Later the rain starts again, permitting the full development of the plant.

⁵ On 23 August 2011, the river basin, with a capacity of 195 m³/s, was flooded by more than 400 m³/s of water. At the entrance to the town of Yautepec, which is in a canyon, the river rose by 21 m in less than half an hour.

Table 4.2 Land use change in the state of Morelos 1977–1994

Land-use changes	1977 (ha)	1994 (ha)	2000 (ha)
Agriculture	185,799	210,251	287,362
Forest	232,774	197,805	151,868
Livestock	67,044	71,552	197,000
Urban areas	7,690	15,380	18,563
Water bodies	793	834	1,085

Source Rueda Hurtado (2006, p. 161) and INEGI (2000)

including the dangerous haemorrhagic dengue. In January 2013, the state health department reported 5,016 cases, mostly in the study region.

Nevertheless, these so-called natural disasters are not only climate-induced but also triggered by anthropogenic factors, such as land use changes, deforestation in both ecosystems, and the erosion of slopes in the mountain region. Table 4.2 indicates the land-use change in the state of Morelos, which is representative also for this basin area that covers 25 % of the state of Morelos. Forests were destroyed, especially the dry tropical forest in the central valley, and land-use change occurred, first for agricultural production and from 2000 on for the extension of urban and suburban metropolitan areas. Today the Canyon of Lobos is linked to the metropolitan area of Cuernavaca (Fig. 4.4), separated only by the protected area of the Sierra Montenegro (Fig. 4.3). Nevertheless, this central natural protected area together with El Texcal is under high social pressure and permanently threatened due to illegal land invasion and destruction of the remaining dry tropical forest.

El Texcal is crucial for the environmental equilibrium of the whole state of Morelos, because this natural park also represents the water reserve for the state (Bendig 2005). Land-use change and pollution of the water reservoir are creating threats for basic ecosystem services such as clean water and air, as well as for pollination processes. The demand for water is limited in the northern part due to its lack of water during the dry period. This creates conflicts between communities, but also between the traditional use of water for agriculture and the new demand for aquatic parks and spas.

Figure 4.5 shows that in the basin half of the surface is used for agriculture, while deforestation has caused almost 89 % of the area to deteriorate. Only 11 % of the original forests and dry tropical jungle have been conserved, due to the high population density in the region, an intensive use of soil for agriculture, and the changes from agricultural use to urban use and weekend houses. Both processes have affected the natural conditions. Together with erosion, deforestation and pollution, natural vulnerabilities have increased (Oswald Spring/Jaramillo 2012), with negative outcomes for the people and thus increasing their social vulnerability. Greater climate variability related to global processes but with local impacts can be observed in agricultural production. While in 2004 13,000 ha of rain-fed land were cultivated, in 2009 the total area fell to 10,000 ha and in 2012 to less than 9,000 ha, figures basically related to the emigration of subsistence farmers and the lack of rain

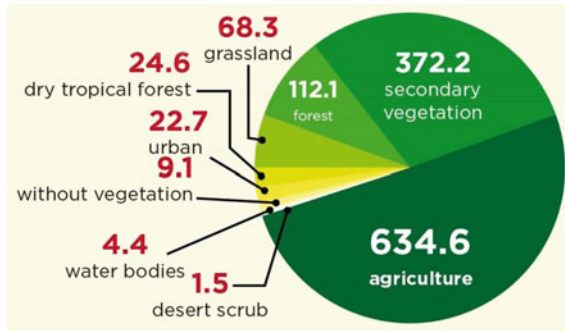


Fig. 4.5 Land-use changes in the Yautepec River Basin (in ha). *Source* Survey conducted by CRIM–UNAM (2010–2012)

for cultivation. The irrigated areas remained constant at 43,000 ha. Many peasant families who and the lack of rain for cultivation depend on the monsoon in the rain-fed land have decided to abandon their plots and migrate as their survival was threatened by periodic droughts and flash floods, where they lost not only their annual harvest but also the seeds for the next year (Oswald Spring et al. 2013).

Within the basin, water consumption is unequal: agriculture uses 95 % of the surface water and 23 % of groundwater, and less for livestock. Sugar cane production and increasingly the production of vegetables employ 16 % of the *economically active population* (EAP) in the basin, but produce only 4 % of the *gross domestic product* (GDP). The industrial sector employs 26 % of the EAP and produces 34 % of the GDP, while the service sector employs 58 % of the EAP and generates 62 % of the regional income. In terms of water use, secondary services use 3 % of surface water and 7 % of groundwater, while the service sector receives 3 % of the water from the rivers and 2 % of the groundwater. Household supply accounts for 67 % of groundwater and only 2 % from surface water in the highlands. The people in the highlands harvest rainwater and during the dry period they buy from water tanks. After the cholera epidemic the use of bottled water was introduced and today 72 % of the people buy their water in jugs, 12 % harvest it from rainwater and 15 % rely on their own well. The imbalance between water use, wealth generation and employment indicates a structural imbalance between water supply, demand and income, and therefore social and political tensions are related to the supply of, access to and availability of water.

Thus the arena of conflict over water supply and disasters in the YRB is historically related to its very specific geological and historical conditions—conditions that are socially aggravated. The permanent tributaries of the YRB originate at more than 5,452 m above sea level on Popocatepetl, on Chichinautzin and in the Tepozteco National Park (Aldama/Arreguín 2003; Aguilar Benítez 1999; Aguilar Benítez et al. 2000). The difference in altitude from Popocatepetl to the flood plain of the YRB, 4,200 m in 27 km, increases the velocity of the water, transporting rocks, waste and trees. These structural conditions have created

processes of *longue durée* forming a complex hydrology with numerous small rivers, often dried out and eroded during the dry season (Braudel 1949) where the *structural development of middle-term* processes is related to deforestation (including the national parks), soil erosion in 80 % of the surface area, a high level of sedimentation in the river bed, and invasion of the basin. The lack of municipal planning and infrastructure has created a vulnerable environment. When a rapid-onset event occurs, such as extreme rainfall, flash floods, or longer periods of drought, the most vulnerable people are deprived of their precarious conditions for survival (Oswald Spring et al. 2013).

From a longer-term perspective, these rivers have flowed into the floodplain, the Yautepec valley, and alluvial sedimentation has accumulated deep soils with high fertility. From ancient times, indigenous cultures—Tlahuicas and Xochimilcos—have developed a sophisticated irrigation system (Mentz 2008; Maldonado Jiménez 1990; Morett Alatorre et al. 2001), facilitating during the dry season several harvests per year, due to the mild subtropical climate. For this reason, the region has been densely populated for centuries and control of it has been taken over several times, first by indigenous groups,⁶ later by the Spaniards, and today by urban landlords.

With the Spanish, the ‘white gold’ brought wealth to a small group of landowners (including the conqueror Cortez), while the indigenous farm workers were exploited and expelled from their land. They have also often lost their means of subsistence, resulting in great inequality and armed struggles. After the revolution, the land was distributed among the peasants, though women were excluded from the benefits, provided that they had actively participated in the war (Sosenski 2009; López González 1980; Meyer 1992). Slowly the land again became concentrated in the hands of landowners, including the urban bourgeoisie, and peasants often do not have enough income to survive from their small plots of land; this has increased the precarious conditions of life in the rural areas (Bartra 2012; García Jiménez 2005).

In the mountain region, inappropriate use of the soil, extensive pastures for livestock in dry tropical forest and over-fertilization have eroded the land. Furthermore, the distribution of small plots of land among numerous male descendants has produced small individual holdings, often resulting in the over-exploitation of these tiny plots of land. All these processes have increased the loss of natural fertility, as well as erosion and desertification, and this has also affected ecosystem services and biodiversity in the pine-oak forest, but especially in the dry tropical forest (Maldonado 1997; Arias et al. 2002; Rzedowski 1978). Hence, the rural population has lost its major supporters of ecosystem services, generating additional pressures on the social subsystem, especially with the relatively high population growth. The absence of conditions for survival in the rural areas has driven

⁶ When the triple alliance of the Aztecs dominated the region, they demanded excessive tributes and the over-exploitation of the Tlahuicas brought inequality. For this reason the king of the Tlahuicas decided to marry his daughter to the emperor of Tenochtitlan, in exchange for a reduction in the amount of tribute.

young people to cities and abroad, but has also increased the social vulnerability of those remaining behind. In the mountain area of the Sierra Madre Sur, corn and bean production was lost around 1990, and after 2005 wind and water erosion also destroyed the rangeland for livestock. These problems were exacerbated by the effects of extreme meteorological events (flash floods in low-lying fields and especially drought in the mountain areas) related to climate variability and climate change (IPCC 2012). People confronted with survival problems have increasingly migrated to the USA. In villages in the south, more than two-thirds of the families today have at least one member who is a migrant in the USA. The lack of safe water and land have also exacerbated local conflicts over the control of water and irrigated land and access to groundwater, where the families of the traditional chiefdoms have grabbed these resources for the benefit of corrupt leaders.

4.4.2 Social Vulnerability

The neo-liberal policy operating since 1985 in Mexico has increased social inequality. In the study areas it has caused acute marginalization (Cagigal Rodríguez 2012, p. 23), and historical poverty has increased. A rapid modernization process, governed by short-term interests of urbanization and land-use change, has created new vulnerabilities and additional environmental degradation.

Furthermore, a policy of the indiscriminate importation of highly subsidized basic products has forced small farmers out of agricultural production because of the collapse in the prices for their crops and the rise in costs. In Mexico in 2013, more than twelve million people experienced hunger; in the state of Morelos about 390,000 people. The loss of livelihood has further increased rural and suburban misery.⁷ Because of their low income, housewives have often chosen to buy cheap junk food, which in the medium term has increased obesity and health problems for children (diabetes). In health terms per 1,000 people, undernourishment still affects 5.3; diabetes 14.6; cancer 74.8; infections 4.1; respiratory diseases 61; gastro-intestinal diseases 10; violence and accidents 8.5; and brain-cardiovascular strokes 21.

Chronic unemployment among men and their migration has forced women⁸ without money to find different survival strategies: borrowing from neighbours or

⁷ Of the people in the Yautepec River Basin, only 13.6 % are classified as living at a “low” level of marginality, while 4.8% % are classed as “very high”, and 39.9 % as having a “high” level of marginality. This implies that 45 % of the population live in extreme poverty. Various government programmes have reduced the illiteracy rate from 11.9 % in 1990 to 6.3 % in 2010; this is related to population growth where children have increased their schooling. Compared with the rest of Mexico, the YRB is still below the national level of 8.6 years’ schooling: in the YRB it is 8.2.

⁸ In Morelos, 30 % of the all households are managed by women, mostly representing the poorest families, where children are obliged to support the family income. These families are also the most exposed to involvement in illegal activities and organized crime (INEGI 2010, 2012).

local shops, selling unwanted goods, organizing cooperatives for selling home-made handicrafts, and recently also providing services such as computer-based work, printing, etc. Many live on irregular land, often obtained by collective invasion. Many women have organized themselves and struggled to obtain basic services and government support (electricity, water, community centres, credit for productive activities, training, crop seeds, animals, other government subsidies), but also for the regularization of their land. These women rely on part-time jobs and multiple activities in services, handicrafts, food, and washing and ironing. Their fight for new public subsidies and poverty alleviation programmes (*Oportunidades*) has empowered these women and in this way they have consolidated their survival strategies (Oswald Spring 1991). Often they are fighting against intra-family violence and for social and economic consolidation, for productive activities, and for their communities and families. Facing unemployment and lack of income, men often become alcoholics, migrate or become involved in illegal activities such as cultivating illegal drugs, retail sale of drugs, or directly with the organized crime.

The first cycle of conflicts is related to unsustainable modernization: the sale of land to urban buyers provided the farmers with a short-term income, but deprived them in the longer term of a productive potential for maintaining, albeit precariously, their livelihood. Members of the family, often the husband and young people, are forced to emigrate, leaving in their places of origin poverty and conflict in the river basin, where the main problem is linked to access to water. A combination of inadequate management of natural resources, a lack of prevention policies and social system pressures related to population growth and short-term economic interests have produced extreme landscape transformation with dramatic losses of ecosystem services. Combined with many more slow on-going processes such as CC, environmental vulnerability has increased socio-economic disasters in which vulnerable people have often lost the conditions for survival and life.

A second cycle of conflicts is related to the change in land use from agriculture to chaotic urbanization. The loss of agricultural land has forced the people to search for jobs in the nearby industrial zones; during economic crises when there was a low demand for labour, the younger people moved to Mexico City or as undocumented migrant workers to the USA (Fig. 4.6). Without doubt, migration represents a coping strategy that is able to reduce socio-environmental pressures. A third cycle of conflict is linked to the young unemployed who join criminal gangs. However, not only does this region experience emigration, but migrants are also returning from the cities, because of unemployment, food scarcity and a lack of social services, due to the prevailing neo-liberal policy of the Mexican government since 1985. Thus, a fourth cycle is linked to intensive immigration from the neighbouring states of Guerrero, Puebla, Mexico and Mexico City, where people look for better conditions of life and jobs. These poor immigrants usually occupy land that is marginal and high-risk, often through collective invasion,

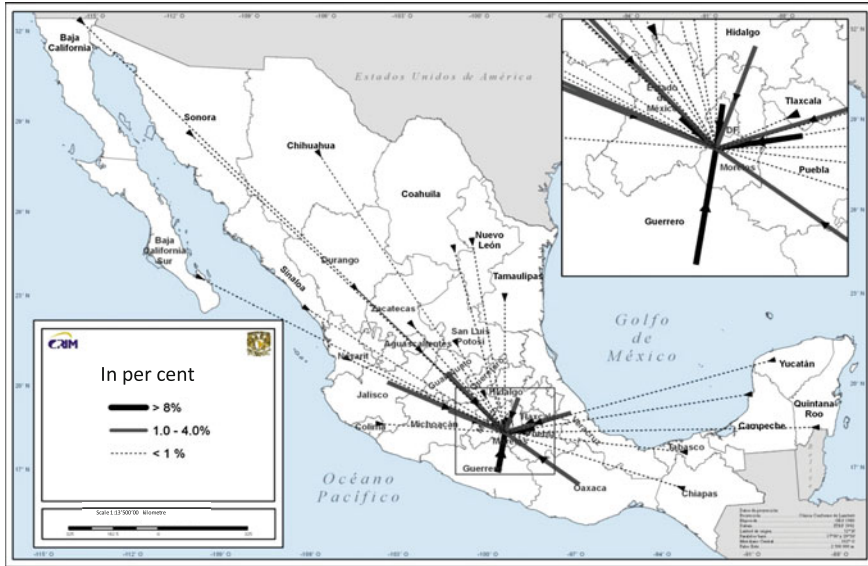


Fig. 4.6 Flows of immigration to Morelos: Source Oswald Spring et al. (2013, in press)

destroying the important ecosystems of the dry tropical forest and water recharge areas (El Texcal), but also putting their own lives at risk. Their houses are constructed out of precarious materials, often recycled from waste. During extreme events these shelters cannot resist flash floods, and sometimes people are buried under the mud; in this way, a link is established between social and environmental vulnerability. These four scenarios of conflict may increase the social and environmental vulnerability of the poorest people, but they also result in conflict constellations in a region facing natural and social challenges that has a high level of social inequity as expressed by the Gini index (Fig. 4.7), especially in *los Altos* (the highlands) of Morelos. In analytical terms, the combination of increasing environmental threats with social precariousness and inequity increases both the vulnerabilities and the negative feedback between them creates greater risks for the most vulnerable people, as well as producing social anomie (Durkheim 1999), personal unrest, alienation, and uncertainty.

Unsafe life conditions are exacerbated by untreated sewage from sugar factories, households, industries, other businesses, and by new dangers related to the use of plastic in households and agriculture. All these pressures are related to an unsustainable consumerism, where solid and liquid waste has increased water pollution. Thus, water has not only become scarce, but it has also been highly polluted, and the lack of urban planning combined with corruption and necessities

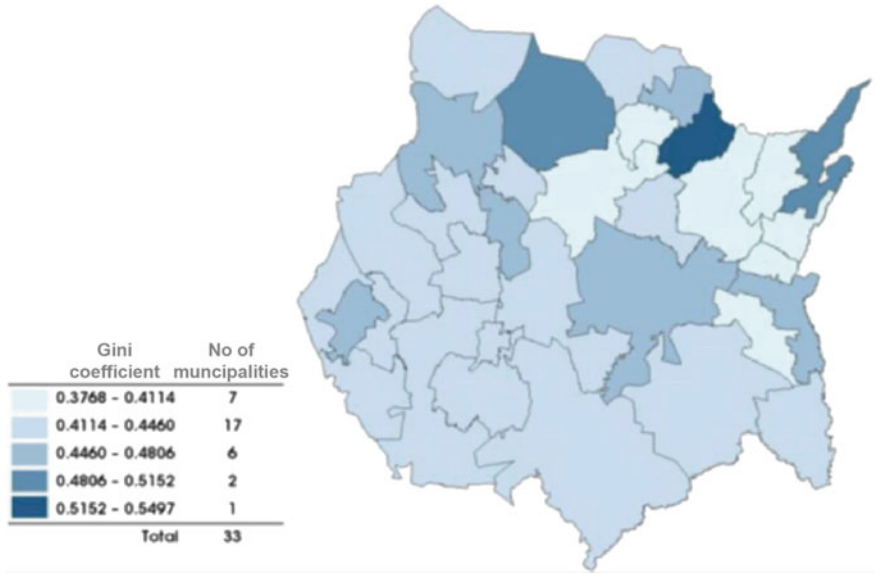


Fig. 4.7 Gini index in Morelos. Source Coneval (2012), p. 26

to land⁹ has allowed several invasions into the river basin. During the rainy season affluents carry this waste downstream and during extreme floods the accumulation of garbage builds levees that finally break under the pressure of water and then flood the urban area, destroying public infrastructure, productive tools, services and agricultural fields. But the liquid and solid wastes also contaminate soil and air, generating vermin, flies, cockroaches, bacteria and viruses and thus facilitating water-borne diseases. By adding the loss of food quality and environmental services, a vicious circle is created where further environmental degradation additionally impoverishes the local population.

Finally, events in the short term, such as organized crime, greater violence and gangs, have brought new unrest into the YRB, triggered by the return of family members who have been expelled from the USA as undocumented migrants, some of them being dependent on drugs and alcohol. Instead of sending remittances, they have become a liability for the extended family, because they often return with no money. They lack a house to live in and some of them have been in jail in the USA for several months before being expelled and so have also been psychologically affected. These social problems are becoming worse due to threats related to climate change, flash floods and droughts.

⁹ These invasions have introduced additional threats during flash floods. They are partially responsible for blocking the flow of water upstream and accumulating waste. Once these obstacles are eliminated, the velocity and amount of water increase, and these phenomena often produce disasters downstream.

4.4.3 *Interaction Between Environmental and Social Vulnerability*

These critical social conditions are further aggravated by public insecurity, the presence of organized crime related to the production of illegal crops, and fighting between criminal gangs for the control of trafficking routes, kidnapping, extortion and robbery. This has resulted in a greater welfare loss, aggravated by crop failures and the failure of the state and federal governments to support communities affected by climate variability. In the Metropolitan Area of Cuautla, public violence, ethnic and political conflicts, chaotic urbanization, migration and accidents involving agrochemicals or technological disasters have not only increased existing social vulnerability, but made it difficult to overcome.

Because of this environmental and social vulnerability, during the past decade poverty has increased (Oswald Spring 2013). The management of forests is still limited to commercial use, and so forest fires are hardly ever prevented, and higher temperatures increase bush fires, and these also affect natural protected areas. 98 % of forest fires are human-induced, and are sometimes caused deliberately to justify or force land-use changes. For this reason, 80 % of the soil in the YRB shows signs of erosion, aggravated by the illegal activities of loggers which are often controlled by organized crime. This interaction of social and environmental factors increases both social and environmental threats and the inadequate waste management in the basin increases the risks of disasters.

This interrelationship of high-risk natural and precarious social conditions creates challenges for the region as a whole and for each community in particular. The different levels of government must reduce and prevent these risks and train people to deal better with existing threats. Initial cooperation between the three levels of government for *disaster risk reduction* (DRR) did not include preventive behaviour. People become aware of a disaster after being harmed and thus their confidence in their authorities is low. Corruption during the post-disaster reconstruction phase has increased distrust in authorities, and this has limited participation by citizens in increasing resilience and adapting to adverse conditions.

Since the 1950s population growth, land-use change, deforestation, and since 2000 rapid urbanization have caused a reduction in forests and jungle, but increasingly also in agricultural land. The natural environment and ecosystem services have deteriorated significantly due to deforestation. Changes in precipitation have increased due to GEC. Developments over several centuries or decades, reinforced by recent changes produced by humans and the climate, require changes in traditional coping strategies. New threats and risks challenge the life, livelihood and well-being of especially the vulnerable people who are often unable to cope with these new threats.

For this reason, when families, neighbourhoods and communities repeatedly face extreme events they organize themselves. They want to understand what has changed and how they can best mitigate the negative outcomes. They call for an integrated management of the river basin and a collective river management plan

to reduce the annual threats and losses by protecting people, infrastructure, wealth and investments.

4.5 Coping Strategies: Bottom-Up and Top-Down Linkages with a Gender Perspective

In the survey the question was raised of what people know about the risks posed by GEC in the Yautepec river basin, and what their past experience was with decision-making processes relevant to coping with changing environmental and social conditions. Most people linked the impact of disasters to hydrometeorological events: 42.4 % to the irregular monsoon season; 29.5 % to longer dry periods; 15.0 % to insufficient precipitation and 13.1 % to too much rain (Fig. 4.8). During four focus group sessions the contradiction between a surplus and a lack of rain was discussed, and the people affected defined it in terms of flash floods, where within a short time large quantities of water flood the plain of the YRB, beyond the capacity of the river bed to cope, while at the same time the dry period is becoming longer, temperatures hotter and the interstitial drought more irregular. All these phenomena affect corn production with too little water during the growing period and too much rain during the period of ripening when the plant requires less. In the survey, farmers mentioned irregular rainfall. This results in complete crop failures or in important reductions in yield, or in increased plagues and pests.

When asked who was responsible for preventing future disasters, 62 % of those interviewed said that both the authorities and the people affected were jointly responsible, while 16 % named the authorities, 14 % the people affected, and 8 % did not know (Fig. 4.9). During the annual extreme events people have learned that they must collaborate with the authorities (Hunter 2005). As a first agreement with citizens, the local authorities have installed a short-term early warning system: when the river rises more than one metre, an initial audible alert automatically

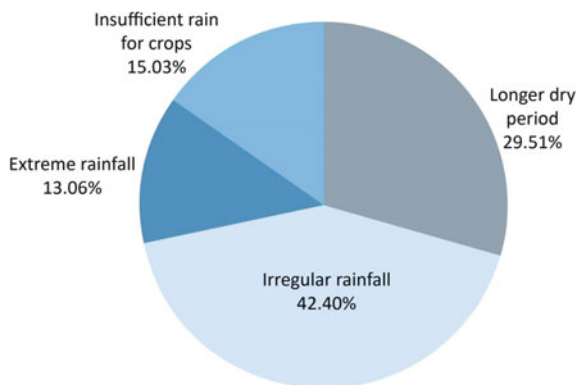


Fig. 4.8 Risks posed by GEC and CC. *Source* Survey conducted by CRIM–UNAM (2010–2012)

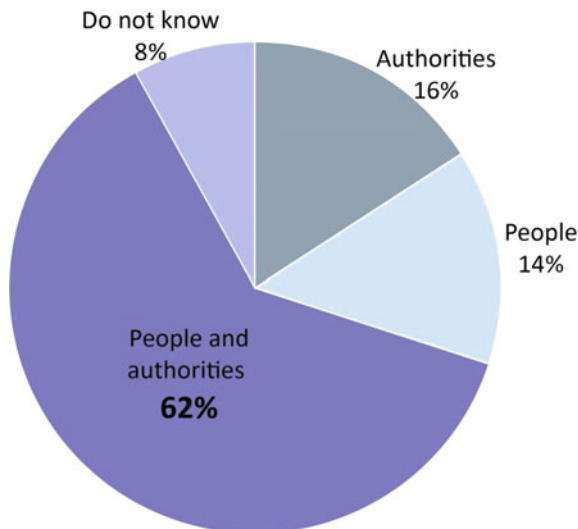


Fig. 4.9 Who is responsible for risks in the Yautepec River Basin? *Source* Survey conducted by CRIM–UNAM (2010–2012)

warns the people; if the river rises more than 1.5 m, a loud siren warns people to evacuate immediately. The velocity of the water sometimes allows only 5 min for evacuation and now, when the rainy season starts, people prepare their important documents so that they can rush to the refuge. The federal government must inform people several days in advance by radio and TV and in local newspapers about the development of tropical storms and hurricanes, both on the Pacific and Atlantic coasts, so that people can prepare for a possible evacuation. There is still no early warning for droughts and the data supplied at the beginning of the dry season are not periodically updated and are often not clear enough to promote a change of crops before the monsoon starts. A better forecast might help the farmers to programme their crops, e.g. to produce crops requiring less water, and in extreme cases not to cultivate the land or to sell their livestock in advance.

The local governments of the municipalities in the basin have collaborated closely with the ministry of the environment and civil protection at the state level and the National Water Commission (Conagua), as well as with scientists, universities and research institutes, affected enterprises, local traders, schoolteachers, and people from the markets, in order to establish an assessment method for adaptation. This has increased the credibility of preventive activities. The sources of information are critically scanned and errors or misinformation are periodically corrected. A first agreement is in place among affected people to develop an emergency plan and to periodically evaluate the early warning system. People who did not receive local information in time or who did not understand the audible warnings were later locally trained, evacuation routes were better marked, and shelters were prepared at the start of the rainy season to avoid children having to miss classes when schools are transformed into refuges.

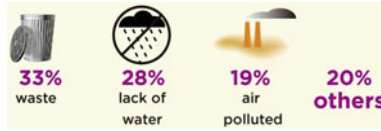


Fig. 4.10 Environmental problems in the Yautepec River Basin. *Source* Survey conducted by CRIM–UNAM (2010–2012)

Once the preventive part and the early warning were settled, then key questions of how to mitigate and to adapt to these new climate and environmental situations were collectively discussed. People understood that environmental and social problems have triggered the negative outcome of extreme events. 33 % of those interviewed insisted that the mismanagement of waste increased the risks; 28 % mentioned the lack of water; 19 % air pollution; and 20 % other problems (Fig. 4.10). On the root causes of the increased frequency of extreme events, 45 % stated that all natural resources are being destroyed; 22 % pointed to air quality and higher temperature; 28 % to a lack of water; and 13 % to the destruction of forests and the erosion of the river basin (Fig. 4.11). Scientific assessment based on satellite images indicated that 80 % of the soil shows different degrees of erosion, from light to severe.

These data show that the region is not only seriously affected by global environmental change but that people are also conscious that the traditional way of dealing with natural events is no longer feasible. Asked directly about local environmental risks, 65 % of those interviewed said that the lack of water was a significant threat, 23 % mentioned floods and 12 % the loss of harvests (Fig. 4.12). The differences are related to farmers with irrigation and those living on the slopes

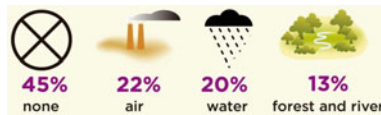


Fig. 4.11 Conservation of resources in the Yautepec River Basin. *Source* Survey conducted by CRIM–UNAM (2010–2012)

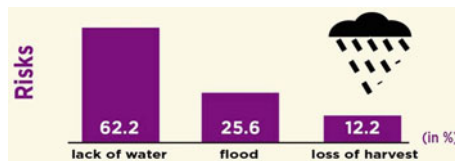


Fig. 4.12 Most important risks for people in the Yautepec River Basin. *Source* Survey conducted by CRIM–UNAM (2010–2012)

of the mountains without the possibility of irrigating their crops. These general differences are reflected in the survival strategies of communities and families affected by GEC.

Progressive deterioration of their purchase power parity (PPP), increases in food prices greater than any increases in their salary, and the long distances between their homes and their work confront migrants in towns with the limits of survival. Some returned migrants argued that they had travelled for 2 h or more every day just to get to a temporary job and then to return home to sleep for a 5 h. In the villages, small plots of land are cheaper, and with an orchard they can plant their own subsistence crops. These people understand that distances within the village are shorter and security is often better than in the suburbs with their organized crime. The cultivation of *nopal* (a cactus) on the high plateau requires additional manpower, and weekend houses offer new opportunities for permanent or temporary jobs.

Finally, there exists an additional gender vulnerability that affects women, children, young people, the disabled and the elderly. Women not only suffer from historical discrimination and violence that they themselves identify as quadruple discrimination (as indigenous, women, migrant and poor; Estrada 2013), but during the migration process their vulnerability increases (Oswald Spring 2012); most migrant women have been raped during their international transit, and girls are often trafficked and sexually exploited (Catholic Church 2008). During disasters they die in higher numbers because of historical discrimination, lack of training, and constructed social representations and trained identities where women care for and protect family members and neighbours, as well as domestic animals (Ariyabandu and Fonseka 2009; Oswald Spring 2008; Birkman 2006), sometimes at the cost of their own lives. Women staying at home face new tasks and challenges as heads of households. They are now responsible for the fields, the household, the education of the children and the household income, but often they also have to care for their parents.

This workload creates enormous psychological pressures and many women require antidepressant drugs to overcome the tensions of coping with these new, unknown and complex tasks. Among these highly vulnerable women and exposed communities, even non-extreme events can produce dangerous impacts and loss of lives and livelihood. Nevertheless, women facing these new roles do not just suffer, but are also empowered. They become responsible for local public services such as schools and water and waste management, where often they must struggle with dominant and well-established patriarchal leaders who are generally extremely corrupt. Their transparent management of the water system, for example, has not only reduced infant mortality and disease, but has also increased the availability of water to houses on the outskirts. Their public involvement is changing traditional local politics. The next steps may be to compete for jobs as municipal president or as local or federal deputies or senators, with new bottom-up ideas about how to address this dual vulnerability to social and environmental deterioration.

4.6 Conclusions: Adaptation for an Alternative Livelihood from the Bottom Up

On the research question of how poor people can adapt in order to overcome social and environmental vulnerability in a high-risk river basin facing the effects of global environmental change, the empirical part of the investigation produced several proposals. Small farmers affected by GEC see different alternatives: (a) change from subsistence crops (corn) to commercial ones (green and red tomatoes), (b) change from commercial crops with higher demands for water to those with lower (sugar cane to sorghum; tomatoes to nopal, etc.), (c) internal and international migration and return migration strategies (Rivera Sánchez 2012) to cope with a more unpredictable environment and with social deterioration. Adaptation processes differ not only at a local level, but also between families and within each family. Most of these families have not yet understood the full impact of regressive globalization (Held/McGrew 2007; Bohle 2001, 2002, 2007) and global environmental change (Brauch et al. 2008, 2009, 2011; Oswald Spring 2011a). Therefore, their adaptation strategy is developed step by step, often with high costs in material and emotional loss, just to maintain or improve their precarious livelihood. Most of the families in the YRB are without government support, so that they need to find a way of dealing with a complicated situation of life and livelihood on their own.

In the YRB, local people understand the complexity (Fig. 4.13) of both environmental and social vulnerability, expressed in their low Human Development Index (HDI). After their adaptation assessment, they have developed adaptation tools and new capacities for dealing with more difficult environmental and social conditions. One crucial theme is related to energy use and efficiency, and the energy returned on energy invested (EROEI) is improved with green agriculture, integrated waste organization and systemic water management (Oswald Spring 2011a). The double vulnerability approach proposed in this chapter on the one hand allows people to train at a local level for human adaptation capacity, and on the other hand, environmental management through the recycling of organic waste, paper, glass and plastic means that people not only reduce the dangers of waste in the rivers, but generate income and new products. The massive reforestation in the upper-stream area allows the infiltration of rain and reduces flash floods and sedimentation. In the YRB, there are still a need for experiments with renewable energy that would be able to consolidate a sustainable economic system with new job opportunities and income. The combination of different sustainable processes may also increase the level of local adaptation, reducing migration and the pressure on women left behind. The double circle of human development in Fig. 4.13 represents a sustainable and efficient way to improve human adaptation to GEC in general, and in the YRB in particular.

By improving ecosystem services and income through a multiplicity of sustainable activities, people are creating an environment with low demand for energy and productive inputs. Composting organic waste can increase natural soil fertility and reduces the need for agrochemicals. Simultaneously, these practices are

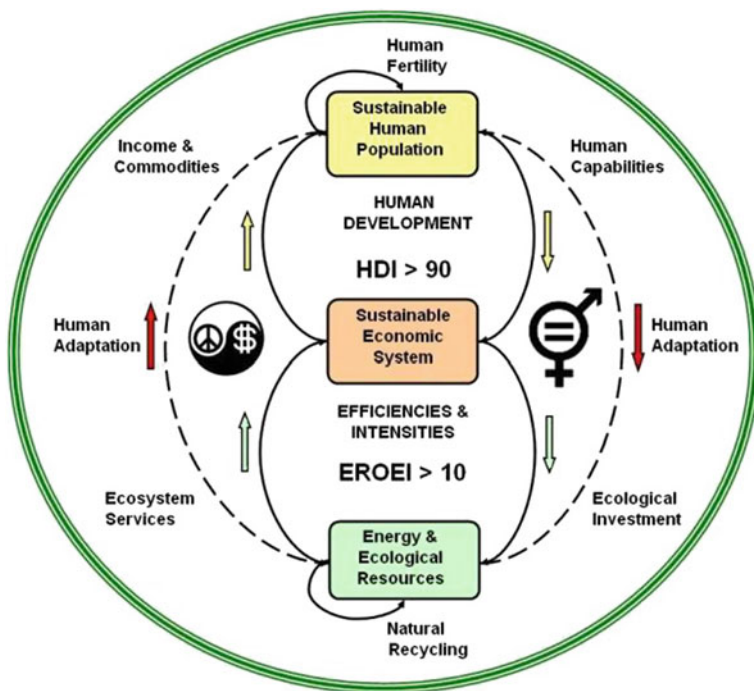


Fig. 4.13 Sustainable adaptation. Source Jackson (2011) p. 195

improving human health and providing knowledge of organic agriculture and environmental services. Women confronted with new roles as head of households because of the migration of their husbands are at the forefront in the field of sustainability. They have changed the productive processes in their fields and have prioritized healthy food for their family instead of cash crops with high inputs of agrochemicals. They have also become involved in public activities and have changed the administration of local public services. With more government support and training, these women could create a sustainable human population at local level. Adaptation is a complex process and women, men, children, adolescents and the elderly must find their way towards human adaptation. Promoting public policies for training to adapt locally means that people can deal better with extreme events. Organized and prepared people are participating more actively in the improvement of their own communities and so are setting out on a constructive and sustainable pathway towards integrated adaptation processes in a high-risk region.

Acknowledgments The empirical study was financed by DGAPA–PAPIIT, IN3000213-2 Manejo integral de una cuenca afectada por el cambio climático: riesgos, adaptación y resiliencia. I am especially grateful to Hans Günter Brauch (Germany) for his comments and proposals throughout the evolution of this chapter, to anonymous reviewers for their extensive suggestions, to Michael Headon (Wales, UK) for his very careful language editing and to Ángel Paredes Rivera (Mexico) for designing most of the figures in this chapter.

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