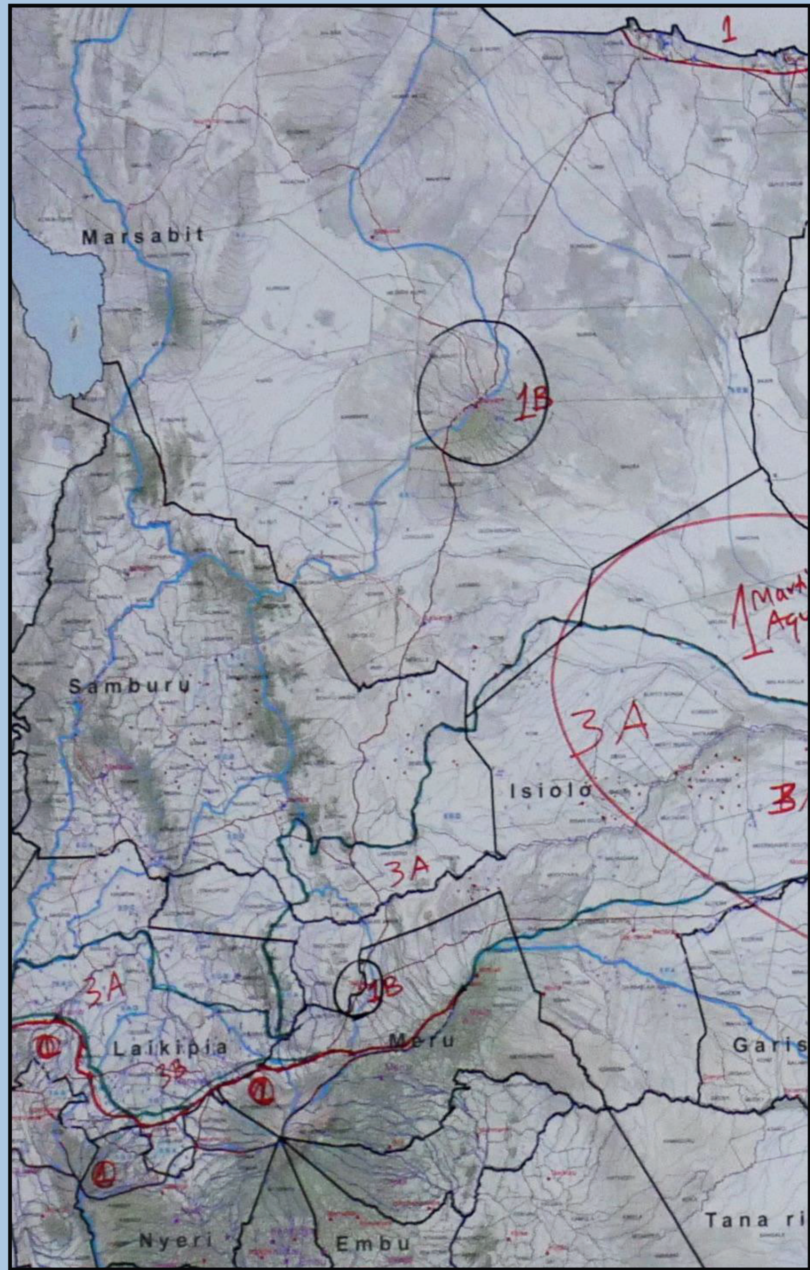
Hotspots of Water Scarcity and Conflicts in the Ewaso Ng'iro North Basin

Identifying context-specific water development priorities through an innovative and participatory approach

Boniface Kiteme



With contribution from:

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CETRAD, April 2020

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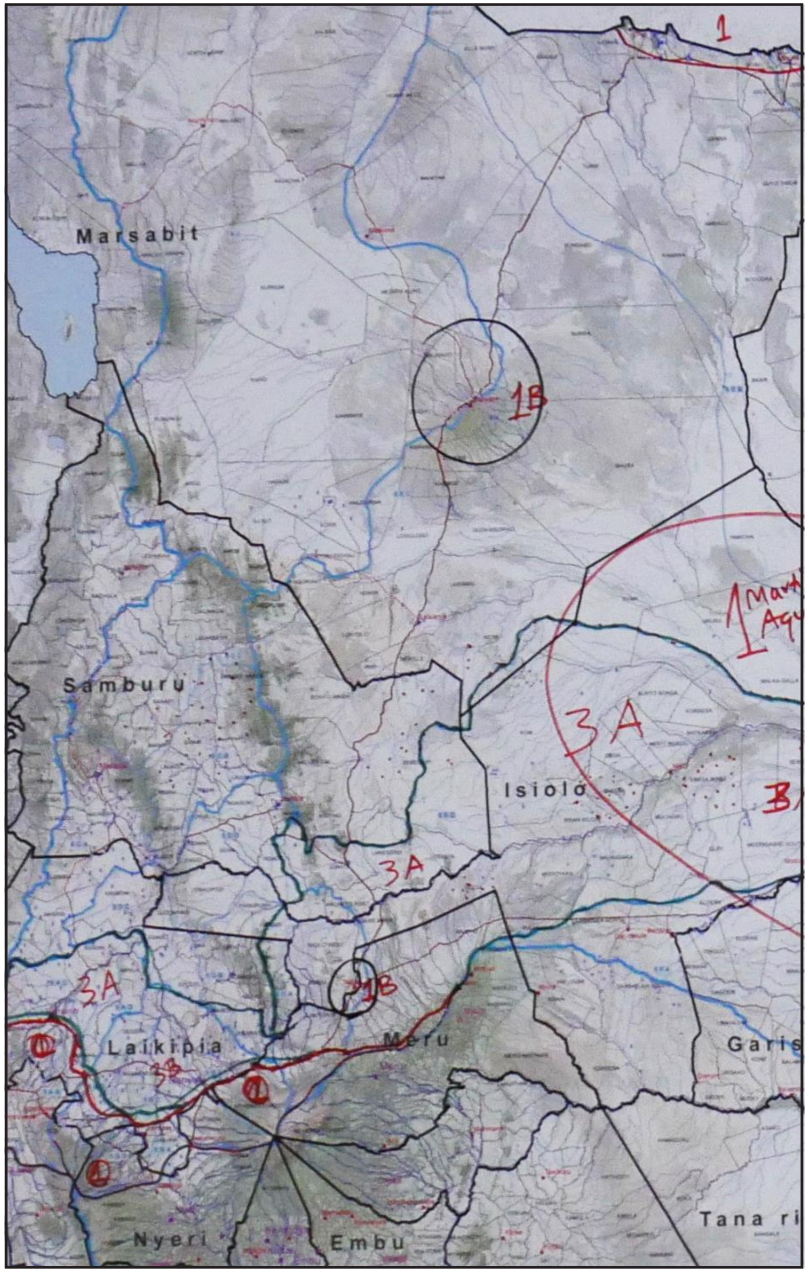

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cetrad@cetrad.org

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Lead Author
Boniface Kiteme (CETRAD)

Figures and maps:
Evans Njuguna (CETRAD), Urs Wiesmann (CDE)

Photo on front cover
Urs Wiesmann (first workshop November 2015)

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Abstract

This report presents an innovative and participatory approach to identifying hotspots of water scarcity and conflicts, exemplified by the Ewaso Ng'iro North Basin in Kenya. Hotspots are areas within the Basin that show problematic situations of water scarcity and/or water conflicts. Hotspots are therefore an important indication of where and how to set priorities of water development in the basin.

The approach combines spatially disaggregated baselines with a participatory assessment involving expert and contextual knowledge, and complements the current state assessment of hotspots with anticipating the impact of future developments under three scenarios, namely peripheral, agrarian and industrial transformations.

The mapping reveals distinct patterns of hotspots, with two complex configurations of hotspots in the upper basin and in the region of the Merti aquifer and a number of less complex and more localised hotspots, thereby clearly indicating priorities, required strategies, and appropriate approaches for water development and conflict mitigation in the basin.

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Acknowledgements

This report is one of the products elaborated under the Water and Land Resources Centre (WLRC) project (April 2011 - March 2019). The WLRC Project was financed by the Swiss Development Cooperation (SDC) and implemented by the Centre for Development and Environment (CDE) of the University of Bern and its partners in East Africa and the Horn of Africa, coordinated by CETRAD, Kenya, and the WLRC, Ethiopia.

The East Africa component emphasised on aspects that promote integrated water resources management and governance at different levels and across scales. Production of knowledge for policy, planning and decision support tools and products, such as this report, was therefore key throughout its engagement. Over the eight years of work in the project, many individuals and institutions were directly involved and made great contributions for which I and the whole WLRC team are highly grateful. While I cannot name all in person I in particular like to single out Prof. Thomas Breu (CDE) for his overall project leadership; Dr Isabelle Providoli (CDE) for her overall coordination responsibility well executed; and the larger coordination team at CETRAD namely John Mwangi, Emma Odera, Milton Mutuma and Jacinta Muchugu.

The insightful revelations, emerging from real time data streams and a series of socioecological assessments, over deteriorating state of water resources and rising cases of related complex water conflicts in the entire basin challenged the project team into a spin. This set the stage for a process of systematic identification of areas with spatially explicit constellations that have the potential to translate into hotspots of water scarcity and conflicts; and determine how such hotspots could evolve under given trajectories of socioecological changes over time. A team of highly motivated experts with broad knowledge of and long standing experience in water resources issues in the basin was assembled to conduct the process and deliver the desired product.

Inspired by the availability of high quality integrated data and information base; and inspired with the prospects to develop a potentially decisive decision support tool for water resources planning and management, the team, through a series of iterative exchanges outlined the principles that such a process could follow. These were subsequently refined and concretised into an innovative and participatory approach for identifying context specific water development priorities for the basin. A novelty!

All the team members involved, whether in their individual or institutional capacities, contributed immensely to the process that ensued and progressed for close to two years. I thank all of them, and in particular those named in the list of contributors for their precious contributions during the initial hotspots assessment workshop and the subsequent scenario building workshops that were critical in shaping the final product of the entire process. In this regard I single out the extra effort provided by the leaders of each thematic transformation scenarios including Josiah W. Mulwa (Industrial Transformation Scenario); Prof. J. Onyando (Agrarian Transformation Scenario) and Jeremiah Njeru (Peripheral Transformation Scenario) and their secretariats – Emma Odera, Milton Mutuma and Evans Njuguna respectively. I, equally, would like to thank their mother institutions for allowing them time off to participate in this hotspots mapping and assessment process.

Special thanks go to Prof Urs Wiesmann (CDE) for providing conceptual scientific leadership throughout the entire scenario development and actual hotspots assessment process; for moderating the two main workshops that conducted the hotspots mapping and scenarios building process; and for helping to structure and draft this report. Without him it would have been difficult to push through the process, integrating all the divergent and at times very conflicting and controversial views, into a solid product of this quality.

Finally, I express special thanks to Evans Njuguna (CETRAD) for his tireless effort during the lengthy back-and-forth consultative process that helped to refine the maps to the state they are published in this report.

Boniface Kiteme, April 2020

1 Idea and objectives

1.1 Water as key-development issue in the Ewaso Ng'iro North Basin

The Ewaso Ng'iro North Basin is one of five large river basins of Kenya, encompassing about 210,000 km^2. It stretches from the peaks of Mount Kenya and the Nyandarua Ranges over the Laikipia Plateau down to the vast lowlands in the North East of Kenya, bordering Somalia and Ethiopia (see figure 1). It represents a typical tropical highland-lowland system characterised by humid to semi-humid conditions in the relatively small upper reaches and semi-arid to arid conditions on the plateau and in the vast lower parts of the basin (see figure 2). As a result of these conditions the most limiting factor for human activities and development in more than 90% of the basin is water with precipitation below the agriculturally critical 600mm annually. Additionally, the high temporal and spatial variability of rainfall aggravates this limitation and leads into a dependency of the lower basin from river water and groundwater largely stemming from Mount Kenya and the Nyandarua Ranges (see also Liniger 1998; Wiesmann et al 1998; Wiesmann et al 2000; Mungai et al 2004; Aeschbacher et al 2005; Liniger et al 2005; Luedeling et al 2015; Providoli et al 2019).

In the past 100 years, and in particular in the decades since the independence of Kenya, the Ewaso Ng'iro North basin underwent drastic socio-economic transition. Large-scale ranching, and in particular immigrating small-scale farmers and recently established large-scale horticultural enterprises transformed the upper basin from its originally pastoralists land use system, which still prevails in large parts of the lower basin. This transition led to a steep increase of population densities, which in combination with the new land use systems dramatically increased the pressure on water resources, in particular on river water (Providoli et al 2019; Ericksen et al 2011; Mutiga et al 2010a; Kiteme et al. 1998a; Wiesmann and Kiteme 1998; and Kohler 1987).

As a result of these developments, problems of water scarcity have aggravated in all parts of the basin and competition and conflicts over water resources have increased within and between communities and within and between the highlands and the lowlands of the basin. Easy and inclusive solutions to these complex issues of water scarcity and conflicts cannot be found, especially when additionally considering the diversity of communities in the basin, the socio-economic power imbalances, the multitude of planning and administrative units, represented e.g. by 10 counties, and the limited natural and financial resources for water supply development (Kiteme et al 2018; Kiteme and Wiesmann 2015; Mutiga et al 2010a; Kiteme and Wiesmann 2008; Kiteme and Gikonyo 2002; Kiteme et al 1998b; Wiesmann 1998; Liniger 1995).

1.2 The idea of hotspots of water scarcity and conflicts

Against the background of the complexity and interconnectedness of water issues in the basin and the absence of 'silver bullet' solutions, approaches have to be found that entangle water problems to a level where solutions to water supply and conflict mitigation can be concretely identified, prioritized, and effectively and efficiently implemented. This entanglement is envisaged with the approach of identifying hotspots of water scarcity and conflicts.

Two basic considerations stand behind the idea of hotspots. First, the issues of water scarcity and conflicts appear in different manifestations and configurations in different parts of the basin, depending on the specific water requirements by populations, land use systems and ecosystems, and on the concrete availability of water resources stemming from the various components of the water cycle. Concretely identifying these manifestations and configurations context-specifically forms the first component of the hotspot approach. Secondly, issues of water scarcity and conflicts may change over time due to socio-economic and land use dynamics and environmental changes, e.g. climate change. Incorporating future trends therefore forms the second component of the hotspot approach.

1.3 Objective of the hotspot approach

The hotspot approach aims at identifying site-specific current and future manifestations and configurations of water scarcity and conflicts in the basin as a basis for the development of context-specific approaches and solutions to water issues. Assessing hotspots of water scarcity and conflicts thereby aims at providing a crucial planning instrument for prioritisation and implementation of water development in the basin.

2 Approach

2.1 Two components of the hotspot approach

The approach to identify hotspots of water scarcity and conflicts builds on two components: First, on the compilation of available baseline data and information concerning environmental conditions, water resources and their variability, land use systems, population, and socio-economic characteristics. The quality of hotspot identification therefore largely depends on the quality of the baselines and especially on their degree of spatial disaggregation. Secondly, on an expert-based and participatory identification of the concrete hotspots through combining baseline knowledge with topical knowledge and in particular with contextual expertise. The topical and geographic accuracy of hotspot identification therefore also largely depends on the knowledge, competence and composition of the participatory team performing this second component.

2.2 Quality of the two components for the basin

The assessment of hotspots of water scarcity and conflicts in the Ewaso Ng'iro North basin met with favourable conditions in both components:

The inter- and transdisciplinary research by CETRAD and its collaborating partners and projects during three decades has created a wealth of baseline information. Besides land use and environmental mapping (Eckert et al 2017; Njuguna et al 2014; UNEP 2014; Notter et al 2007; Kohler 1987) the long-term hydro-metrological monitoring system (MacMillan et al 2005; Mungai et al 2004; Ojany and Wiesmann 1998;) provided crucial data on water resources and their changes over the time, and especially reveal the degradation of river water due to over-utilisation. The hydro-met monitoring system, which was originally confined to the upper basin, was recently expanded to include downstream tributaries, as well as spring and groundwater monitoring in the lowlands (Providoli et al 2019). CETRAD additionally provides detailed information on the land use and socio-economic transitions, such as the development of small-scale farming and agribusinesses in the upper basin (Zaehringer 2018; Luedeling et al 2015; Lanari 2014; Ulrich et al 2014; Ulrich et al 2012; Schuler 2004). This information is supplemented by detailed and high-resolution socio-economic data for the overall basin through the socio-economic atlas of Kenya (Wiesmann et al 2014, Wiesmann et al 2016), that informs on population numbers and characteristics, poverty rates, and economic activities down to the sub-locational level and for each sub- catchment of the basin. Although more information in particular on water resources and their use in the lower basin would be useful, the baselines provided by CETRAD and its partners are quite unique in the African context and enable a high factual quality of the hotspot assessment.

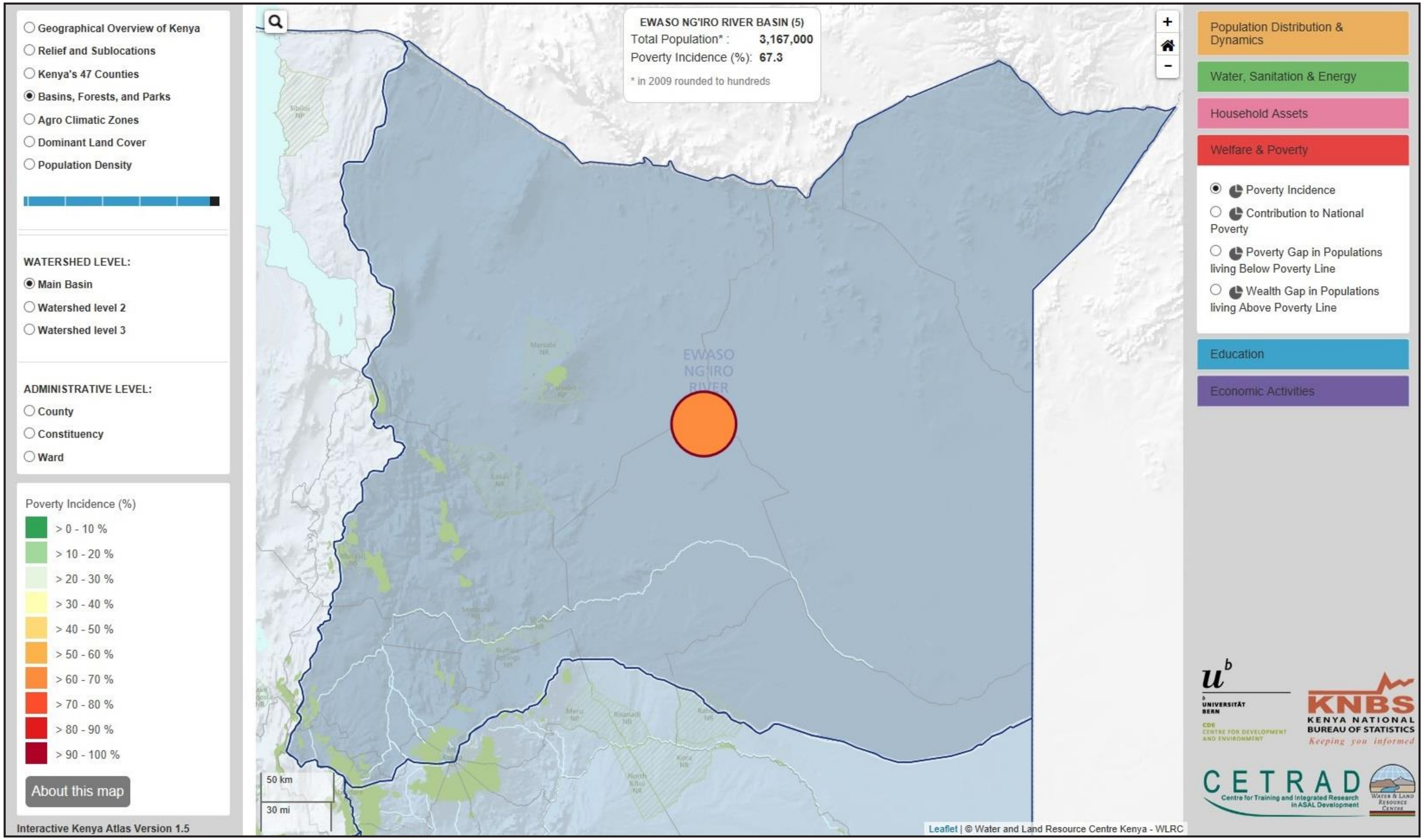

Figure 1: Geographical extent and population of the Ewaso Ng'iro North basin.

The figure indicates perennial rivers, forests and natural parks, as well as the total population (3,167,000) and the overall poverty rate (67.3%) in the basin. Source: Clip from interactive socio-economic atlas of Kenya, www.kenya-atlas.org, Wiesmann U., et al, 2016.

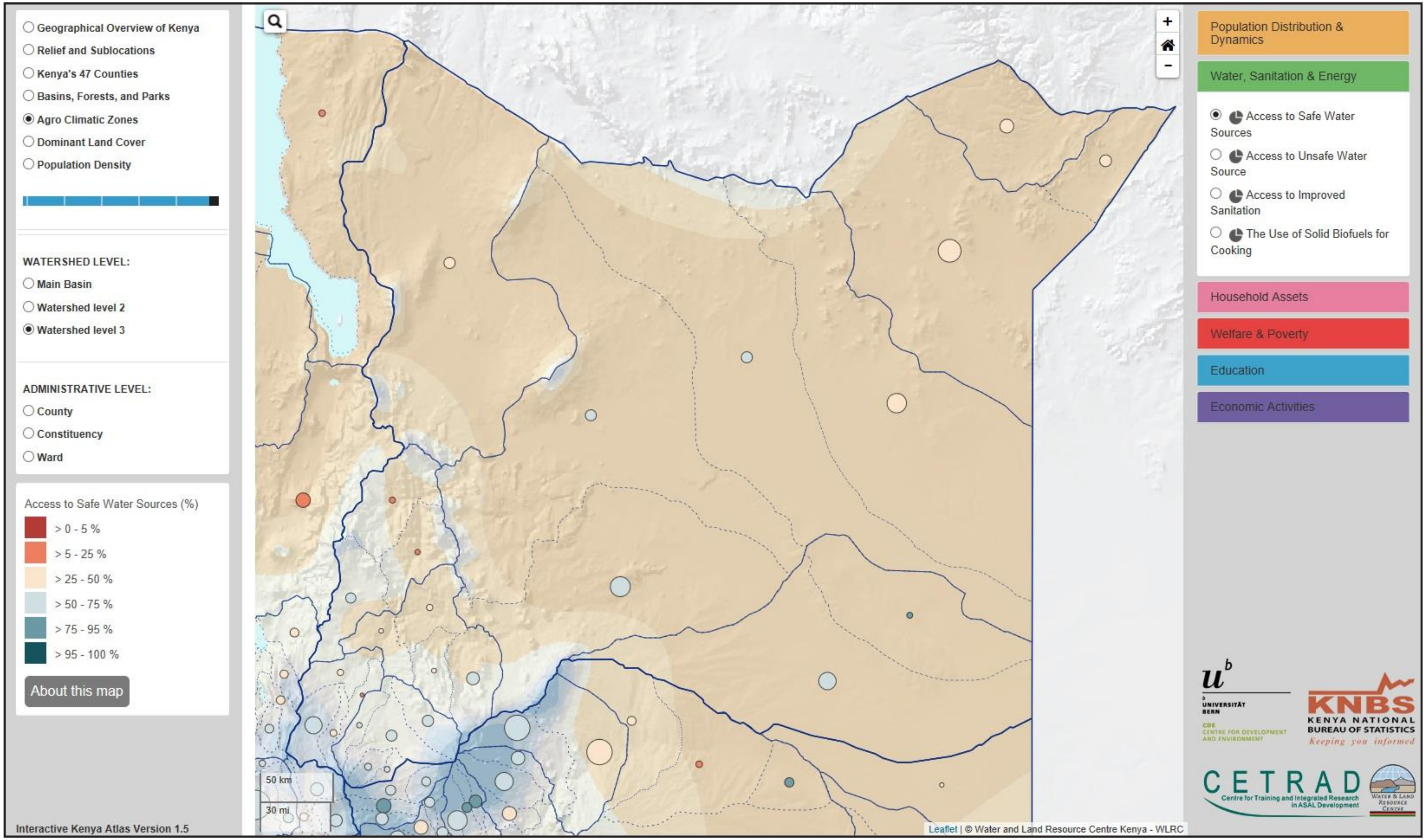

Figure 2: Agro-ecological zones and access to safe water in the Ewaso Ng'iro North basin.

The figure shows the distribution of agro-ecological zones from semi-humid (blue) to arid (brown), indicates sub-catchments of the basin, and depicts the percentage of households per sub-catchment with access to safe domestic water, whereby the size of signatures indicates population size. Source: Clip from interactive socio-economic atlas of Kenya, www.kenya-atlas.org, Wiesmann U., et al, 2016

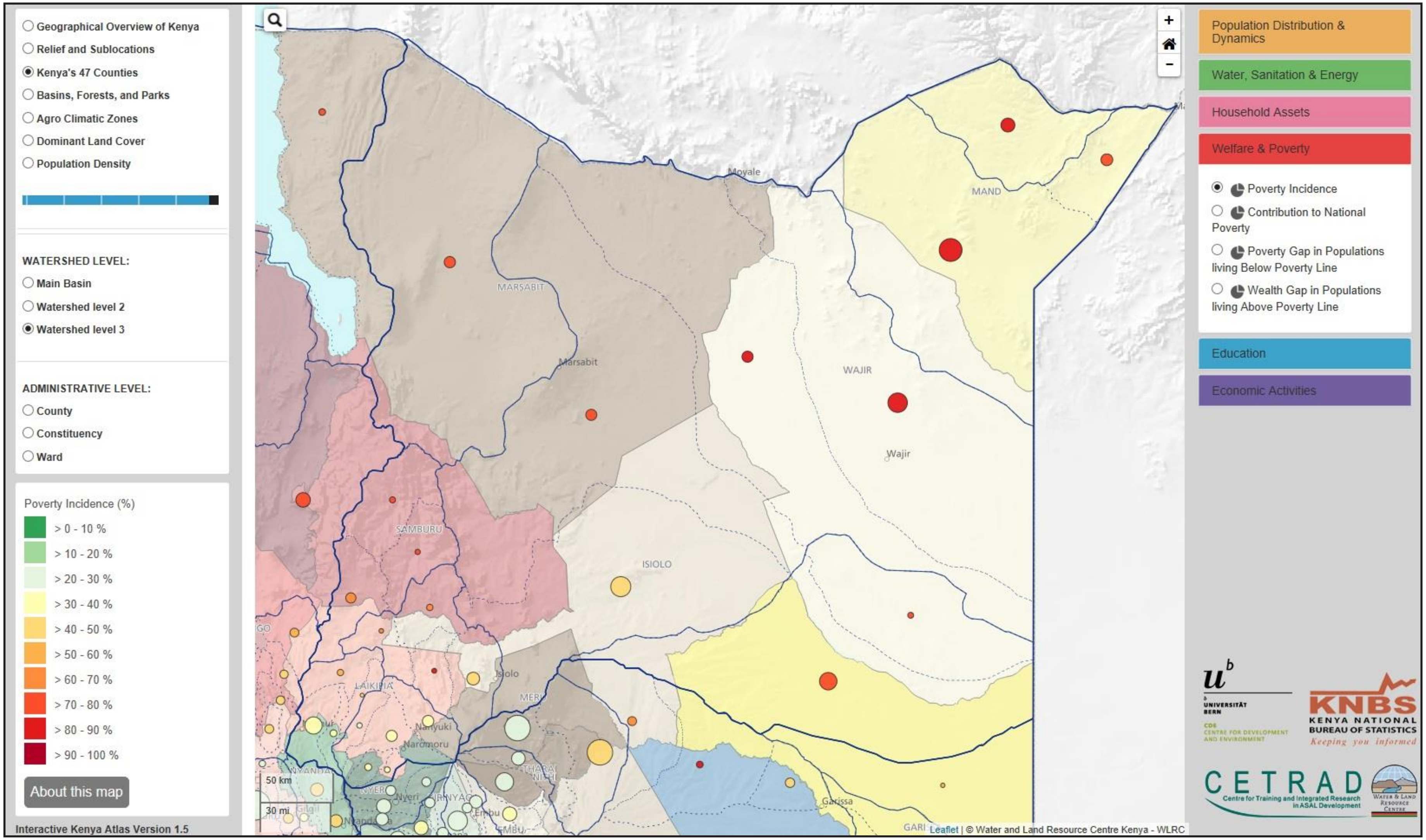

Figure 3: Counties and poverty rates in the Ewaso Ng'iro North basin.

The figure shows the 10 counties fully or partially within the basin and depicts the poverty rates for each sub-catchment. Source: Clip from interactive socio-economic atlas of Kenya, www.kenya-atlas.org, Wiesmann U., et al, 2016.

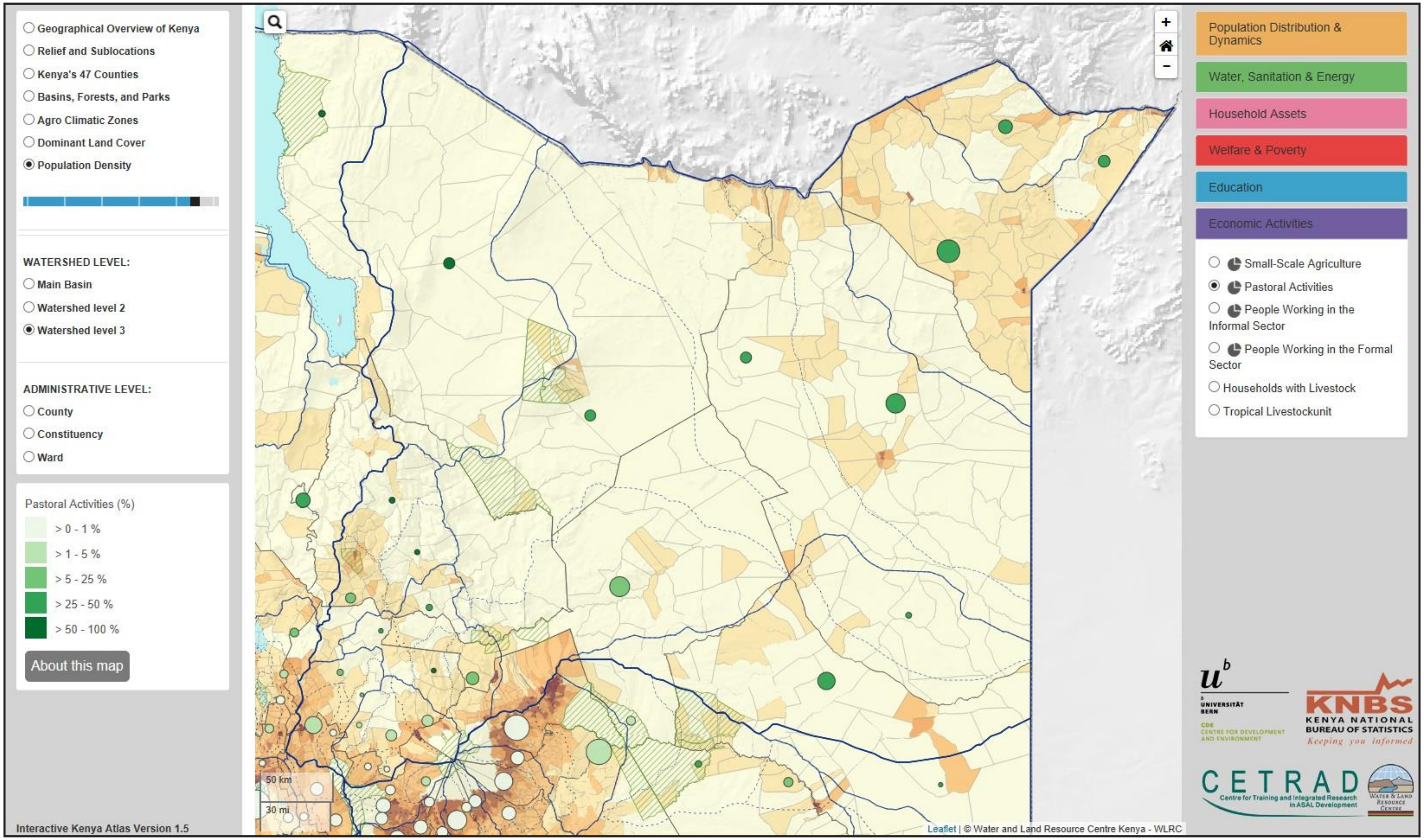

Figure 4: Population densities and pastoral activities in the Ewaso Ng'iro North basin.

The figure shows population densities from more than 200 pers/km^2 (brown) to less than 10 pers/km^2 for each sub-location and depicts the percentage of the labour force engaged in pastoralism per sub- catchment. Source: Clip from interactive socio-economic atlas of Kenya, www.kenya-atlas.org, Wiesmann U., et al, 2016.

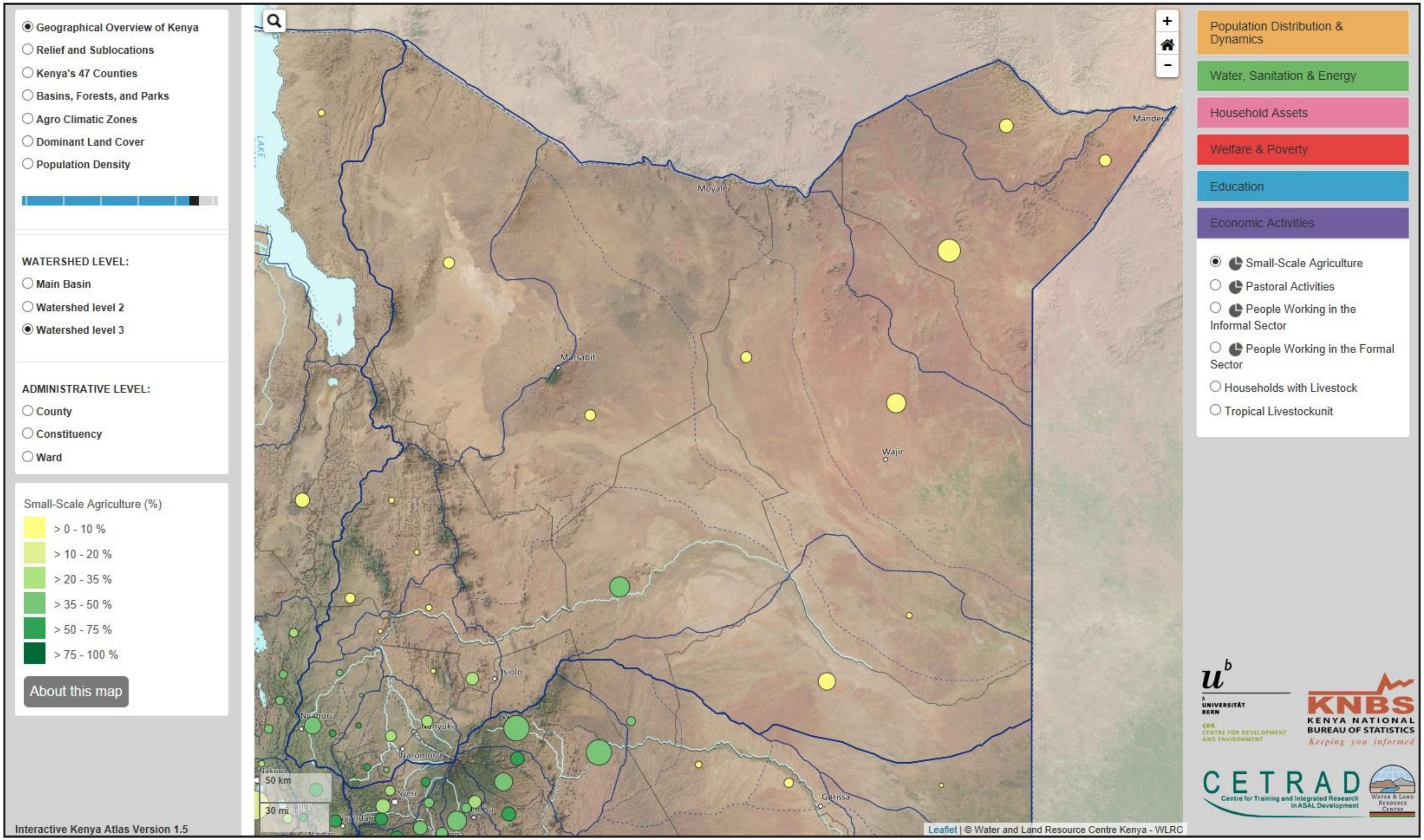

Figure 5: Satellite overview of and small-scale agriculture in the Ewaso Ng'iro North basin.

The figure shows a composite of satellite images for the basin and depicts the percentage of the total labour force being engaged in small-scale agriculture per sub- catchment. Source: Clip from interactive socio-economic atlas of Kenya, www.kenya-atlas.org, Wiesmann U., et al, 2016

Due to CETRADs long-term collaborative networks and its rooting in the field, a well-balanced team could be composed that included the topical and contextual expertise to perform the actual assessment of hotspots in the second component of the approach. The team included experts and stakeholders from county and national governments departments and ministries, civil society, private sector, as well as academia (Ott and Kiteme 2016; Pohl et al 2010) (see also the list of contributing authors).

2.3 Two workshops at the core of the approach

The concrete approach for the assessment of hotspots of water scarcity and conflicts in the Ewaso Ng'iro North basin included four steps of which two participatory workshops formed the core.

In the *preparatory step*, topographical maps, satellite imagery and especially all the available baselines were compiled by CETRAD to be displayed and consulted during the participatory workshops.

In a *first workshop* in November 2015, the participatory team first agreed on the definition of four types of hotspots of water scarcity and conflicts before then mapping the hotspots in three groups. The three assessment maps were then compared in the plenary and in intense discussions consolidated into one map of the current hotspots. Based on this map the team finally discussed sustainable development approaches for each hotspot.

In a *second workshop* in August 2017, the same participatory team defined and spatially mapped three scenarios of future socio-economic and land use developments in the basin. The scenarios were not designed according to probability but in order to mark a field of possible developments within which the actual development will, with high probability, take place. For each of these spatially explicit scenarios it was then assessed what their impact on the current hotspots would be, or if new hotspots may occur under a certain scenario. In combination, the four maps of the current hotspots and three future hotspots provide a spatially explicit planning instrument for water development and conflict mitigation in the basin.

In a *final step* the results of the two workshops were compiled by CETRAD and presented in this report. Of importance is that members of the participatory team could again give further input and feedback.

3 Definition and types of hotspots

3.1 Definition of hotspots

The basic idea behind hotspots is simple. They mark contexts of water deficiency in the sense that water demand surpasses available water resources. This leads to the following definition of a hotspot:

A hotspot of water scarcity and conflict is an area where the total usable water resources are at any given time less than the total water demand.

The *usable water resources* thereby include three types of water: (1) water generated in the area, in particular in-situ rainfall, (2) water present in the area, such as groundwater and springs, or (3) water passing the area, e.g. in form of river water. The total usable water resources in a specific area is the quantitative sum of the three types of water of good quality and their reliability level over time. The quality and reliability requirements of water resources depends on the type of water use, e.g. domestic water use requires higher quality and reliability levels than other uses, such as e.g. water for agricultural production. These requirements imply that the total water resources e.g. for domestic use are principally smaller than the total water resources for agricultural production.

The *total water demand* includes demands for (1) domestic, (2) livestock, (3) urban, (4) industrial, and (5) agricultural use, as well as (6) ecological functions, including preservation of biodiversity of fauna and flora. The total water demand therefore does not only include water quantity, but also reliability and quality requirements by the various demands. Therefore, the total water demand is the sum of the six types of water demand under consideration of the specific quality and reliability requirements by each type of demand.

3.2 Four types of Hotspots

Based on the above definition and the experiences of the participatory team in the Ewaso N'giro North basin four types of hotspots of water scarcity and conflict can be differentiated:

Type 1 In-situ hotspots: In this type in-situ water resources, in particular precipitation, local run-off and small local aquifers, are the predominant resources in the area and are not enough to cover the total water demand at the required reliability levels over time. This type mainly occurs in rural settings such as areas of small-scale farming, agro-pastoralism, conservancies, and in particular in pastoralists areas. The main characteristic of this type of hotspot is that water resources are not developed enough, e.g. by rainwater harvesting and storage facilities, or that they are not accessible to certain types of demand, e.g. when pastoralists cannot access water points in access-restricted conservancies.

Type 2 Groundwater hotspots: In the areas of these hotspots, groundwater and springs are the predominant water source that are shared among different uses and communities and that are used beyond the recharge rates of the aquifers. Typical for these hotspots is that different uses are conflicting, e.g. between and among different agricultural production systems, as well as e.g. with urban supply schemes. These hotspots can be aggravated if the recharge of aquifers is negatively influenced by land and water use outside of the areas of the hotspots, e.g. by changing run-off and infiltration ratios in the source areas of the aquifers.

Type 3 Catchment hotspots: The areas of these hotspots refer to sub-catchments in the basin in which various uses rely on surface water as their main water source and in which problems of distribution of river water occur between different uses or communities, and in particular between upstream and downstream. These hotspots are typically found in sub-catchments of tributaries to the Ewaso Ng'iro North river. Conflicts mainly occur during dry seasons, when small-scale farming communities, agribusinesses and/or urban water intakes compete over low flows. These hotspots are aggravated in case the competition over river water leads to over-utilisation in the sense that residual discharges out of the sub-catchment cannot be maintained, especially in dry seasons. In these hotspots it is also problematic when land use changes, e.g. forest depletion, lead to changes in run-off and infiltration ratios, thereby increasing high flows and decreasing low flows.

Type 4 Highland-lowland hotspots: This hotspot type is basically similar to the sub-catchment hotspot as competition over river water is at the centre of water conflicts and over-utilisation of water resources. The difference is that the highland-lowland hotspots refer to a larger context encompassing the sub-catchments of several tributaries leading into one stream, which cannot maintain its importance for downstream populations and ecosystems due to over-utilisation in the upper parts of the hotspot, in particular during the dry seasons. This type of hotspot is typical for tropical-highland lowland systems with drier lowlands being dependent on the river water generation and use in the more favourable uplands. Water scarcity and conflicts in highland-lowland hotspots are especially complex because they are normally split by major political, socio-economic or ecological boundaries, thereby making planning and development processes, as well as conflict mitigation more challenging. In addition, highland lowland hotspots normally include several catchment hotspots (see type 3) which implies that the competition over river water in the sub-catchments leads to a reduction of outflow from these catchments, that can sum up to a significant degradation of the main stream, thereby massively affecting downstream systems. Complexity in these types of hotspots is further increased by the danger that conflict mitigation of water distribution in sub-catchment hotspots may strongly conflict with mitigation processes at the level of the encompassing highland lowland hotspot, unless residual discharges are negotiated and maintained for each sub-catchment hotspot.

3.3 Legend of hotspot maps

The legend of the hotspot maps for the Ewaso Ng'iro North basin (see Figures 6 to 9) basically differentiates between the above four types of hotspots of water scarcity and conflicts. However, some types of hotspots can occur in combination, in particular type 2 (groundwater hotspots) and type 3 (sub-catchment hotspots), which in the legend are combined in the category of 'catchment and groundwater hotspots'. As mentioned above, type 4 (highland lowland hotspots) in most cases spatially include type 3 (sub-catchment hotspots). But this combination was in the map not merged into one category in order to keep the map explicit on the two types, thereby implicitly implying that upstream sub-catchment hotspots are also part of the adjunct overall highland lowland hotspot.

4 Current hotspots (2017)

Based on the process outlined in chapter 2 current hotspots of water scarcity and conflict were assessed and mapped in a participatory process. The result is presented in the map of current hotspots (see figure 6), representing the state and knowledge of 2017.

Although low and highly variable rainfall causes problems of water scarcity for all livelihoods and ecosystems in the basin, the map shows a distinct pattern of different types of hotspots, thereby indicating where water development and conflict mitigation should be prioritised. The following main observations can be drawn from the map:

First, it can be noted that, contrary to general assumptions on highland lowland systems, the highland-lowland hotspot does not cover the overall basin, but concentrates in its upper parts. At the same time, it reveals that the highland lowland hotspot includes catchment hotspots all along its upper reaches, where population densities and economic activities are especially high. This creates a very complex situation with competition over water in catchment hotspots conflicting with distribution problems at the overall highland-lowland hotspot. The fact that the dry flow of the Ewaso Ng'iro North river has in the past decades reduced by 90%, (Kiteme et al 2019; Kiteme et al 2008; Wiesmann et al 2000; Wiesmann et al 1998) thereby strongly affecting downstream livelihoods and ecosystems, underpins the severity of this hotspot configuration in the upper basin.

The second complex hotspot cluster refers to the groundwater hotspot of the Merti aquifer, which is related to the spring-fed catchment hotspot of the Ewaso Ng'iro North river feeding into the area of the aquifer. The multitude of agricultural, agro pastoral and pastoral water demands in this hotspot is overlapped by distant urban claims on groundwater, e.g. the planned water corridor to the Wajir town. To what extent the groundwater resources are already over used beyond recharge, cannot yet be scientifically quantified. However, the fact that conflicts already prevail and that the aquifer has a transnational extension into Somalia, underline the current and future importance of this hotspot configuration.

The other hotspots of water scarcity and conflicts in the basin are less complex as they are confined to more localised conditions and do not include different types of hotspots. They can be grouped into two: First, in situ hotspots that mainly affect pastoralists and that mainly relate to underdevelopment of and reduced accessibility to water points for domestic and livestock use. These local hotspots principally cover most parts of the pastoralists areas in the lowlands, but are especially pronounced where other uses, such as expanding conservancies and increasing agro pastoral use are restricting the accessibility of water for pastoralists. Secondly, catchment hotspots that are not linked to larger highland-lowland systems. Such hotspots are especially pronounced in and around the resource island of Marsabit and along the perennial and non-perennial border rivers to Ethiopia in the Moyale (Laga Walmur and Laga Badan) and Mandera (river Dauwa) regions. In these regions competition and conflicts between agricultural, pastoralist and urban demands on the same surface water resources prevail.

In sum, the map of current hotspots of water scarcity and conflicts reveals that water development and conflict mitigation is complexly challenged in two areas of the basin; the upper basin with its highly conflictous highland lowland hotspot, and in the area of hotspot configurations in the region of the Merti aquifer. Although severe as well, the other hotspots in the region can be addressed with localised and site-specific approaches. In that sense, the map points to the main thrusts and priorities of water development and conflict mitigation in the Ewaso Ng'iro North basin.

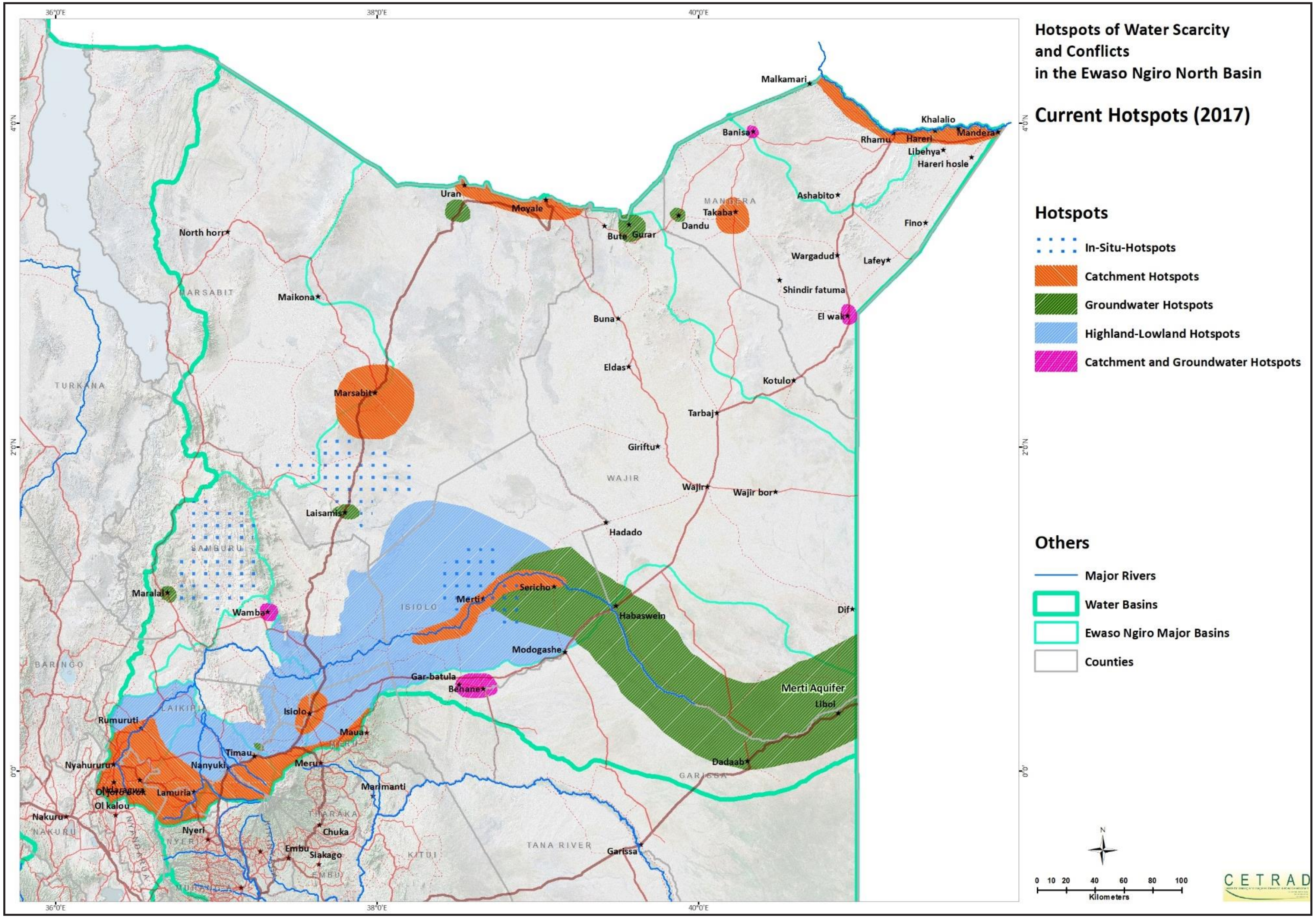

Figure 6: Current state of hotspots of water scarcity and conflicts in the Ewaso Ng'iro North basin (2017)

5 Three scenarios

Although the map of current state of hotspots of water scarcity and conflicts gives important indications for where and how to approach water issues and related conflicts in the basin, it however does not consider future trends and developments that may change or aggravate hotspots. In order to include this dimension into hotspot mapping for developing sustainable long-term strategies, scenarios of future socio-economic and land use developments in the basin are used to complement the hotspot approach (see chapter 2). The basic idea of the scenarios is not to assume the most probable trends of development, but to use three scenarios to span a field of potential developments in which the future in reality will most probably take place. The scenarios define land use and socio-economic developments, which then are interpreted, in a participatory process, concerning their potential impacts on the hotspots. Three such scenarios were differentiated through the following narratives.

5.1 Scenario 1: Peripheral transformation

In this scenario, the socio-economic and infrastructural development of the vast dry lowlands, which constitute the largest part of the basin, will continue to lag behind the high-potential areas of Kenya. In conjunction with the projected further natural population growth and the over-utilisation and degradation of pastoral resources, this will continue to deepen the crisis of pastoralism. As a result, the economy in this region will increasingly be dominated by small-scale informal activities. With poverty rates remaining high, selective outmigration of the most productive and educated labour force will continue. Contrary to that, the upper basin and especially the footzones of Mount Kenya and the Nyandarua ranges will as part of the high-potential Kenyan highlands continue their transformation towards market-oriented agriculture and small-scale industry, thereby increasing the socio-economic disintegration and the divide between the upper reaches and the rest of the basin.

5.2 Scenario 2: Agrarian transformation

In this scenario the basin will be firmly incorporated and linked to the overall national economy. The trends for agrarian transformation observed in the Kenyan highlands will spill over to the basin, with originally strongly subsistence oriented mixed small-scale farming transforming into market-oriented agriculture with more specialised and intensified production. This type of agriculture will develop and spatially further expand especially in the current catchment and groundwater hotspots, where water resources appear to be available. This will be accompanied by increasing sizes of small-scale farming enterprises and by the establishment of some agribusinesses even in the lower basin. Pastoralism will undergo further transformation with sendentarisation and semi-sedentarisation increasing and the shift to agro pastoralism taking place around the agricultural development areas. The remaining pastoralists will further diversify their livelihoods by increased engagement in the informal sector, but also by changing strategies to more market oriented livestock production. Contrary to scenario 1, urban centres will become more vibrant and serve as regional market hubs in these processes of agrarian transformation.

5.3 Scenario 3: Industrial transformation

In this scenario the driving force of development will be the realisation of the Lamu Port South Sudan and Ethiopia Transport (LAPSSET) Corridor with its main and secondary corridors (see figure 9). This supra-regional economic infrastructure will trigger urban and industrial development, e.g. in the field of infrastructure maintenance and services, especially in the vicinity of the corridors, where population densities will also increase. Agricultural transformation will take place similarly to scenario 2, but less pronounced and less spatially expansive. Transformation and sedetarisation of pastoralism will also be similar to scenario 2, but with stronger concentration around the economic hubs along the corridors. Overall, and contrary to the other two scenarios, the economic power balance between the upper and the lower basin will be more levelled.

5.4 Probability of scenarios

It is important to reiterate that scenarios do not aim at representing the most probable trends but rather to span a field of potential developments in which the future in reality will most probably take place. It would even be wrong to assume that one of the above three scenarios is more probable than the others. This would hinder an approach to water development and conflict mitigation that takes into account the hotspots of all three scenarios and therefore is prepared for all development pathways within the field spanned by the scenarios.

We use few examples to illustrate the importance to not attribute probabilities to the single scenarios: One decade ago, most experts might have attributed the highest development probability to scenario 1 (peripheral transformation) as the development of semi-arid and arid areas did not constitute a major national priority. However, with the Kenya Constitution 2010, the processes of devolution and the respective functions and means of the county governments, development pathways in the direction of scenario 2 (agrarian transformation) or even 3 (industrial transformation) may have become more probable. If the national and international mega-project of the LAPSSET will be concretely realized, probabilities will shift further. The multitude of future triggers of development may even result in a mosaic of developments where some areas of the basin take the pathway of scenario 1 whereas other areas may develop in direction of scenario 2 or 3. These examples illustrate how important it is to consider the overall field of future developments spanned by the three scenarios instead of attributing probabilities to single scenarios.

6 Future hotspots

The above scenarios can be used to estimate the effect of the future socio-economic and land use developments on the current hotspots. This was performed in a participatory and expert-based process (see chapter 2), resulting in three maps of future hotspots of water scarcity and conflicts (figures 7 to 9).

Basically, the same legend as in the map of the current hotspots (see figure 6) could be used, but is complemented by additional features and categories for the scenarios of agrarian and industrial transformation. In both maps two categories were added: A category which indicates the spatial expansion of catchment hotspots and a category which indicates significant increase of pressure on groundwater. In addition, the map on scenario 3 (industrial transformation) shows the corridors of the planned LAPSSET and introduces a new category of hotspot that refers to problems of surface and groundwater pollution which do not play a significant role in the current situation, as well as in the other two scenarios.

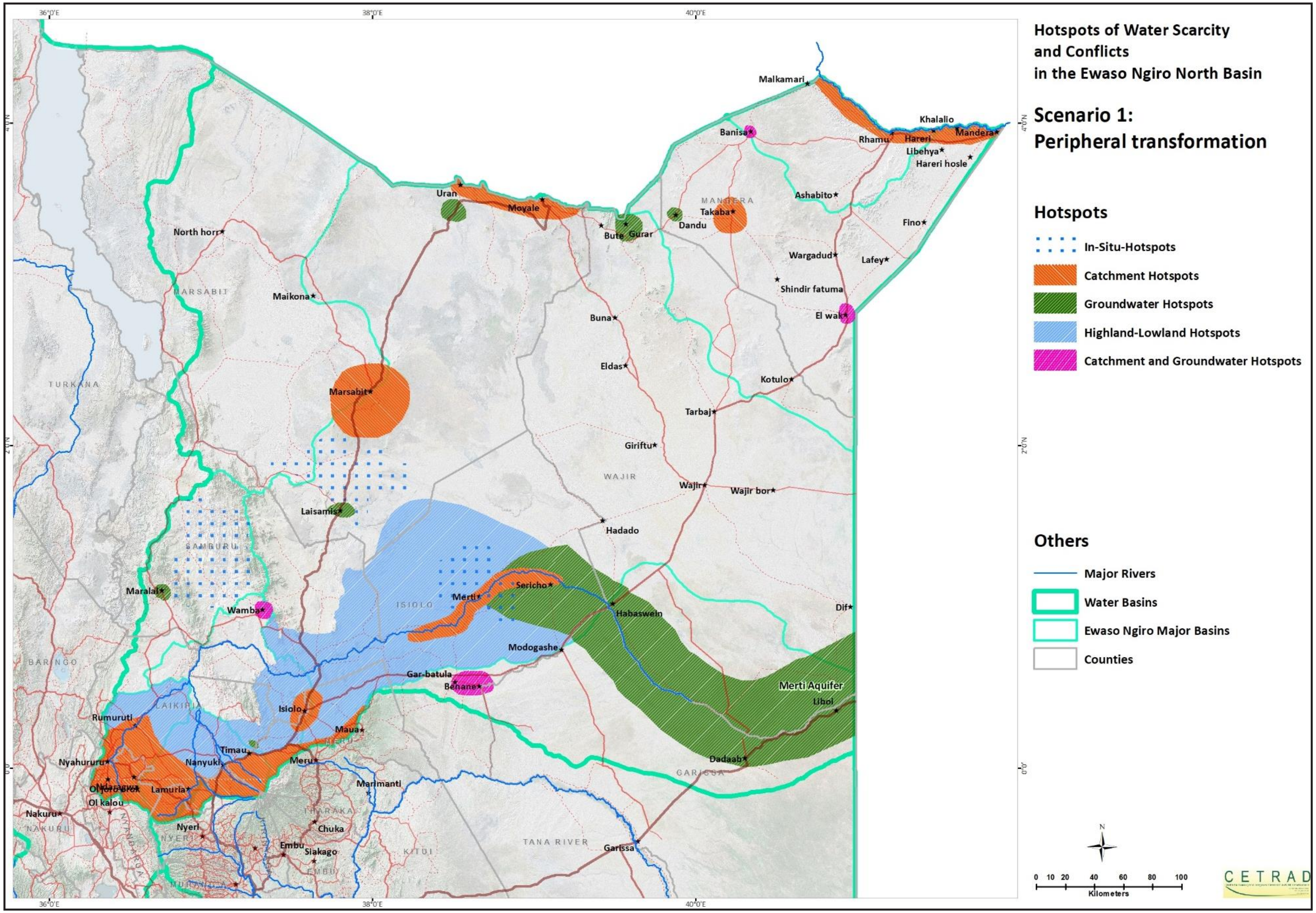

Figure 7: Hotspots of water scarcity and conflicts under scenario ‘peripheral transformation’

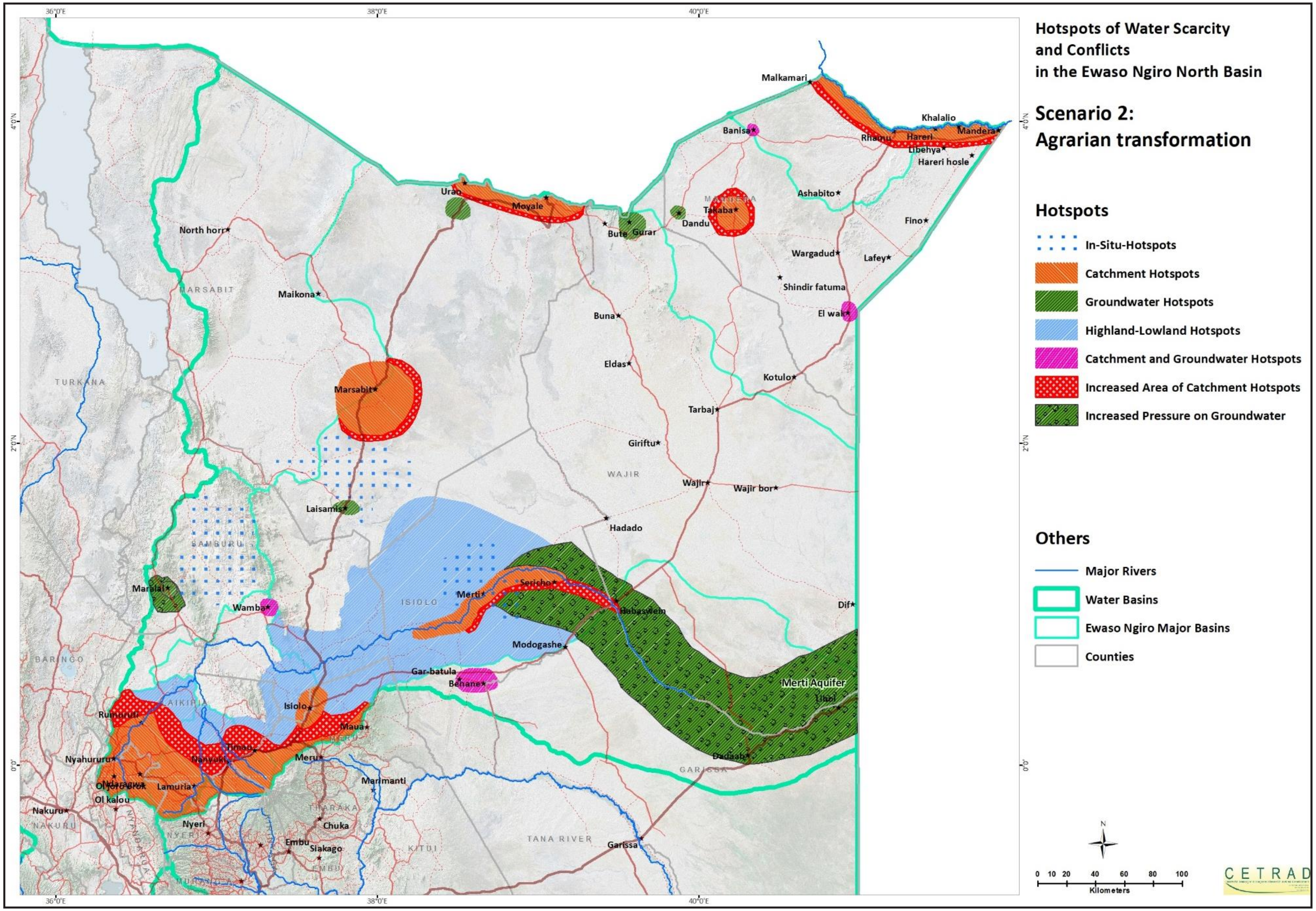

Figure 8: Hotspots of water scarcity and conflicts under scenario 'agrarian transformation'

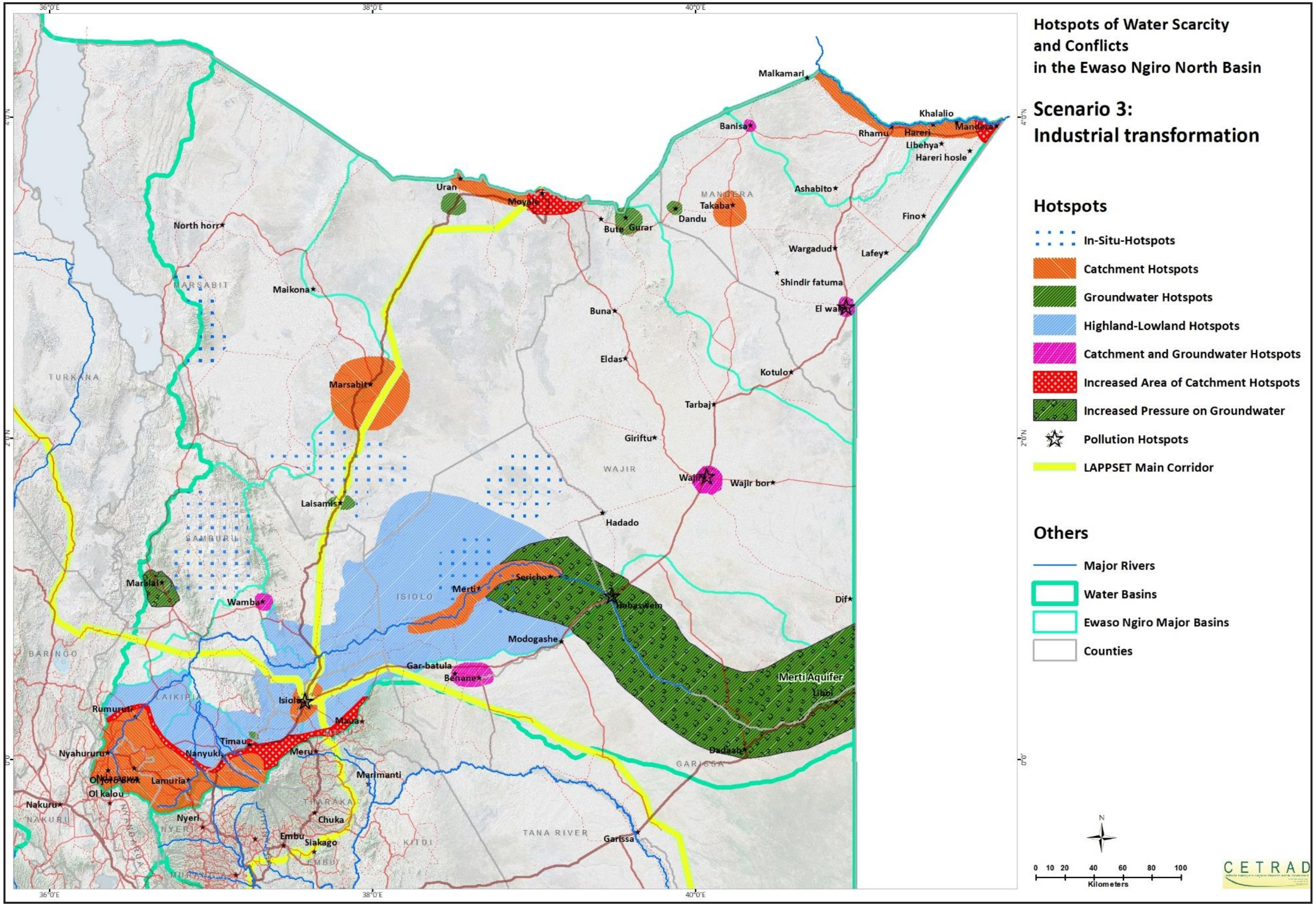

Figure 9: Hotspots of water scarcity and conflicts under scenario 'industrial transformation'

7 Synopsis of the four hotspot maps

Synoptically assessing the four maps of current and future hotspots of water scarcity and conflicts (figures 6 to 9) enables to come up with some general observations that are relevant to strategies and approaches to water development and conflict mitigation in the basin.

7.1 Current hotspots remain relevant

The four maps show that the current hotspots of water scarcity and conflicts remain relevant and important in all three scenarios. In the scenario of agrarian and industrial transformation, many of them further aggravate, whereas pressure in some of the hotspots in the scenario of peripheral transformation will reduce to some extent. However, considering the prevailing high poverty rates in the basin under this scenario, water scarcity will remain a major threat to local livelihoods. These observations imply that the current hotspots are appropriate key-entry-points for water development and conflict mitigation in the basin (see chapter 5) that also take account of possible future developments. In other words, building on the current hotspots for sustainable water development strategies and approaches lays the basis to cope with long-term future developments.

7.3 The upper basin remains a key-concern

The overlap of catchment hotspots with high internal competition over surface water with the highland lowland hotspot remains a key concern in all scenarios. Under industrial transformation, and more so in the scenario of agrarian transformation, catchment hotspots will aggravate and even spatially expand, thereby worsening the problem of residual discharge of the Ewaso Ng'iro North river for downstream populations and ecosystems. In the scenario of peripheral transformation this effect will be less pronounced, but considering the widening socioeconomic and political power gap between upstream and downstream, the effects will be similarly grave for downstream populations and ecosystems. This synoptic analysis implies that approaches and negotiations on surface water in the upper reaches of the basin remain a very high and urgent priority.

7.4 Special attention required on the great aquifer

Experts in the participatory assessment agreed that the planned water corridor from the Merti aquifer to Wajir town will most probably not be realised in the near future. In spite of that it can be expected that the configuration of hotspots related to the large groundwater hotspot of the Merti aquifer will massively aggravate under the two scenarios of agrarian and industrial transformation. Thereby, increased pressure will not only concern groundwater itself, but also its recharge due to the increased surface water use in the adjunct catchment hotspots. Particularly important will be the pressure on spring-fed Ewaso Ng'iro North river before it reaches the region of Merti. Recharge may also be affected by changes in the high flows of Ewaso Ng'iro North river or its episodic tributaries, e.g. in the case of realising the planned mega river dams. Whereas pressure on groundwater resources in the scenario of agrarian transformation will mainly result from increased demand by market-oriented agriculture, agribusinesses, and also agro pastoral use, severe competition over groundwater resources in the scenario of industrial transformation will evolve between local agricultural demand and distant urban and industrial demands. Taking all these considerations into account, the complex configuration of hotspots around the Merti aquifer may in future turn into a constellation, which is as grave and conflictous as the situation in the upper basin. To avoid, or to cope with this situation it is important to urgently develop appropriate planning and negotiation approaches in an early stage. This need also requires a better understanding and spatio-temporal monitoring of the water cycle in the region, in particular processes and rates of recharge, as well as the role of springs and tributaries for the overall water resources availability.

7.5 Site-specific approaches to the other hotspots

Although the other hotspots of water scarcity and conflicts in the basin may be as grave for the concerned populations and livelihoods, they are less complex than the two configurations of the upper basin and of the Merti aquifer. This means that local, context-specific solutions and approaches to water development and conflict mitigation can be participatorily developed for them. Of high priority are catchment hotspots, such as the ones in the Marsabit, Moyale and Mandera regions, which are foreseen to aggravate or even to expand in one or more of the future scenarios. This is especially important against the danger that these catchment hotspots may grow to form new supra-regional highland lowland hotspots. But also the in situ hotspots require urgent and continuous attention, as they heavily affect pastoralist communities and livelihoods in large parts of the lowlands. This is particularly important in contexts where access to water points is restricted by other uses and claims, such as the mushrooming conservancies or, in the case of industrial development, the restricting corridors of the LAPSSET. Finally, special attention is also required to the increasing water demands by urban and industrial developments, especially if the future trends go towards the scenarios of agrarian or industrial transformation. Solutions, which are based on local water resources, such as untapped groundwater pockets, should be prioritised in order not to aggravate other hotspots through distant demands. Especially in case of the scenario industrial transformation, issues of potential water pollution will have to be addressed from the onset of these developments through strict law enforcement and appropriate protection measures.

In sum, the synopsis of the current and future maps of hotspots confirm the strategic thrusts for water development and conflict mitigation derived from the analyses of the current hotspots (see chapter 4). In addition, the synopsis enables to prospectively set priorities and to come up with appropriate and timely approaches in view of sustainable solutions for all hotspots of water scarcity and conflicts in the basin.

8 Conclusions and outlook

8.1 Conclusions

The novel and participatory approach of hotspot mapping presented in this report leads to the following conclusions:

(1) The approach of hotspot mapping has proven to effectively and efficiently disentangle the complex water issues in the basin. The spatially explicit mapping of different types of hotspots enables to set priorities in water development and conflict mitigation in the basin. Knowledge-based priority setting in this field was largely missing up to now.

(2) The preconditions for successful hotspot mapping are sufficient and spatially disaggregated baselines on ecology, water, land use, and socio-economy, as well as a carefully and inclusively composed team of experts and stakeholders to perform the mapping. The participatory team also forms the basis of social and political ownership of the results and acts as transmitter to and champions in their respective institutions.

(3) The typology and characteristics of the delineated hotspots enables to develop context-specific water development and conflict mitigation strategies and approaches for each hotspot. It also gives clear indications on the decision-making levels and administrative units to be involved and indicates the communities and the range of stakeholders to be considered in context-specific and participatory approaches.

(4) Going beyond the current state of hotspots by anticipating their future development through the scenario building approach has added considerable value to priority setting and approaches to water development and conflict mitigation. It also gives clear indications on monitoring and information needs, e.g. in the field of springs and groundwater in the Merti region. In addition, the developed scenarios of peripheral, agrarian and industrial transformation can form a crucial base for policies and planning beyond the water sector.

8.2 Outlook

The results of the hotspot mapping presented in this report form a crucial baseline for water development and conflict mitigation in the basin. They imply the following steps to be followed up:

(1) The results of the hotspot mapping and respective priority settings have to be anchored at all relevant decision-making and planning levels. Based on the ownership already created within the hotspot mapping team, a process of information, transfer and negotiation is to be initiated that aims at broad socio-political agreement on the hotspots. This process has already been initiated by CETRAD and respective authorities.

(2) Monitoring of critical variables for evidence-based approaches and negotiations has to be guaranteed. The hotspot mapping has revealed that this is especially critical in the complex hotspot configurations of the upper basin and of the Merti region. This implies that the well-established long-term hydro-met monitoring in the upper basin is maintained and that the monitoring, in particular of springs and groundwater in the Merti region, is further established and respective data made available for interpretation, planning and negotiation. In addition, baselines on land and water use as well as on socio-economic characteristics dynamics require regular updates.

(3) Concrete and site-specific approaches to water development and conflict mitigation for all major hotspots can be developed and their implementation supported in collaboration with partners, stakeholders and concerned communities. Developing such approaches for the two complex hotspot configurations mentioned above will thereby require a well-tuned and planned socio-political process involving all relevant decision-making levels from the local to the inter-county.

(4) The approach of hotspot mapping presented here was developed for the Ewas Ng'iro North basin. Opportunity-driven, this approach can be offered to and applied in other basins of Kenya and beyond. At the same time, the three scenarios developed can be used in planning processes in other development fields than water, e.g. poverty reduction, food security, urban and infrastructural development, or conservation, among others.

In sum, these conclusions and outlook highlight that the hotspot mapping forms a crucial milestone within the complex and long-term processes of water development and conflict mitigation in the Ewaso N'giro North basin.

Abbreviations

ASAL	Arid and Semi-Arid Lands
CETRAD	Centre for Training and Integrated Research in ASAL Development
ENNCA	Ewaso Ng'iro North Catchment Area
ENNDA	Ewaso Ng'iro North Development Authority
GIS	Geographical Information System
ILRI	International Livestock Research Institute
IT	Information Technology
KM	Knowledge Management
LAPSSET	Lamu Port South Sudan Ethiopia Transport
NRM	Natural Resources Management
RTD	Retired
UNEP	United Nations Environment Programme

References

Aeschbacher J, Liniger HP, and Weingartner R. 2005. River Water Shortage in a Highland–Lowland System: Case Study of the Impacts of Water Abstraction in the Mount Kenya Region. Mountain Research and Development Vol 25 No 2 May 2005: 155–162

Eckert S, Kiteme B, Njuguna E, Zaehringer JG. 2017. Agricultural expansion and intensification in the foothills of Mount Kenya: A landscape perspective. Remote Sensing 9(8): 784.

Ericksen P, Said M, Leeuw J, Silvestri S, Zaibet L, Kifugo S, Sijmons K, Kinoti J, Ng'ang'a L, Landsberg F, Stickler M. 2011. Mapping and valuing ecosystem services in the Ewaso Ng'iro Watershed. Submitted to World Resources Institute (WRI) and DANIDA 23 May 2011

Kiteme B, Mwangi J, Odera E, Liniger HP, Providoli I, Wiesmann U. 2019. Promoting Equity, Peace and Sustainability through Society-Rooted Institutions: Four Decades of Learning, Innovation and Action in Kenya. In: Providoli I, Gete Z, Kiteme B, Amare B, Mwangi J, editors. 2019. Shaping Sustainable Socio-Ecological Landscapes in Africa: The Role of Transformative Research, Knowledge, and Partnerships. Bern, Switzerland: Centre for Development and Environment (CDE), University of Bern, with Bern Open Publishing (BOP). DOI: 10.7892/boris.125341

Kiteme BP, Wiesmann U, Liniger HP, Kohler T. 2018. Water for peace: Mt. Kenya's water resources users associations. In: Jianchu X, editor. Mountain Futures: Inspiration and Innovation from the World's Highlands. Nairobi, Kenya: World Agroforestry Centre.

Kiteme B, Wiesmann U. 2015. A grass-roots solution for water governance in Kenya. In: Ehrensperger A, Ott C, Wiesmann U, editors. Eastern and Southern Africa Partnership Programme: Highlights from 15 years of Joint Action for Sustainable Development. Bern, Switzerland: Centre for Development and Environment (CDE), University of Bern, pp. 31–34.

Kiteme BP, Liniger HP, Notter B, Wiesmann U, Kohler T. 2008. Dimensions of global change in African mountains: The example of Mount Kenya. IDHP International Human Dimensions Programme. IHDP UPDATE 2:18-23.

Kiteme BP, Wiesmann U. 2008. Sustainable river basin management in Kenya: Balancing needs and requirements. In: Hardon GH, Hoffmann-Riem H, Biber-Klemm S, Grossenbacher-Mansuy W, Joye D, Pohl C, Wiesmann U, Zemp E, editors. Handbook of Transdisciplinary Research. Dordrecht, the Netherlands: Springer, pp. 63–78.

Kiteme BP, Gikonyo J. 2002. Preventing and resolving water use conflicts in the Mount Kenya highland–lowland system through water users' associations. Mountain Research and Development 22(4): 332–337.

Kiteme BP, Wiesmann U, Künzi E, Mathuva JM. 1998a. A highland–lowland system under transitional pressure: A spatio-temporal analysis. Eastern and Southern Africa Geographical Journal 8 (Special Number): 45–54.

Kiteme BP, Liniger H, Mathuva JM. Wiesmann U. 1998b. Multi-level approach for enhancing ecological sustainability: Applications within a dynamic regional context. Eastern and Southern Africa Geographical Journal 8 (Special Number): 91–96.

Kohler T. 1987. Land-use in Transition. African Studies Series A5. Bern, Switzerland: Geographica Bernensia.

Lanari N. 2014. Development of the Commercial Horticulture Sector Northwest of Mount Kenya from 2003 to 2013 and Its Impact on River Water Resources of the Upper Ewaso Ng'iro Basin [Master's thesis]. Bern, Switzerland: University of Bern.

Liniger HP, Gikonyo J, Kiteme BP, Wiesmann U. 2005. Assessing and managing scarce tropical mountain water resources: The case of Mount Kenya and the semiarid Upper Ewaso Ng'iro Basin. Mountain Research and Development 25(2): 163–173.

Liniger HP, Gichuki FN, Kironchi G, Njeru L. 1998. Pressure on land: The search for sustainable use in a highly diverse environment. Eastern and Southern Africa Geographical Journal 8 (Special Number): 29–44.

Liniger HP. 1995. Endangered Water: A Global Overview of Degradation, Conflicts and Strategies for Improvement. Development and Environment Reports 12. Berne, Switzerland: Centre for Development and Environment.

Luedeling E, Oord AL, Kiteme B, Ogalleh S, Malesu M, Shepherd KD, De Leeuw J. 2015. Fresh groundwater for Wajir – ex-ante assessment of uncertain benefits for multiple stakeholders in a water supply project in Northern Kenya. Frontiers in Environmental Science. doi.org/10.3389/fenvs.2015.00016.

MacMillan L. and Liniger H.P. 2005: Monitoring and modelling for the sustainable management of water resources in tropical mountain basins – the Mount Kenya example. In: Huber, U.M., Reasoner, M.A., Bugmann, H. (Eds.): Global Change and Mountain Regions: A State of Knowledge Overview. Kluwer Academic Publishers,Dordrecht.

Mungai DN., Ong CK., Kiteme BP., Elkaduwa W., Sakthivadivel R. 2004: Lessons from two long-term hydrological studies in Kenya and Sri Lanka. Agriculture, Ecosystems and Environment Journal 104: 135 - 143

Mutiga, J.K., Su, Z. and Woldai T. 2010a. Impacts of agricultural intensification through the upscaling of suitable rainwater harvesting technologies in the upper Ewaso Ng'iro North Basin, Kenya. HESS (under review).

Mutiga, J.K., S.T. Mavengano, S. Ahongbo, T. Woldai, and R. Becht. 2010a. Water allocation as a planning tool to minimize water use conflicts in the Upper Ewaso Ng'iro north basin, Kenya. Water Resource Management 24: 3939-3959.

Njuguna, EC, Kiteme B, Peter E. 2014. Sub Catchment Directory for Upper Ewaso Ngiro River Basin. CETRAD, Nanyuki. Kenya.

Ojany, F.F., Wiesmann, U., 1998: Resources, Actors and Policies. Eastern and Southern Africa Geographical Journal, Vol. 8, Special Number. 1-3.

Notter B; McMillan L; Viviroli D; Weingartner R; Liniger HO. 2007.Impacts of environmental change on water resources in the Mt.Kenya region. Journal of Hydrology 343(3-4): 266-278.

Ott C, Kiteme B. 2016. Concepts and practices for the democratisation of knowledge generation in research partnerships for sustainable development. Evidence and Policy 12(3): 405–430.

Pohl C, Rist S, Zimmermann A, Fry P, Gurung GS, Schneider F, Speranza CI, Kiteme B, Boillat S, Serrano E, Hirsch Hadorn G, Wiesmann U. 2010. Researchers' roles in knowledge co-production: Experience from sustainability research in Kenya, Switzerland, Bolivia and Nepal. Science and Public Policy 37(4): 267–281.

Providoli I, Gete Z, Kiteme B, Amare B, Mwangi J, editors. 2019. Shaping Sustainable Socio-Ecological Landscapes in Africa: The Role of Transformative Research, Knowledge, and Partnerships. Bern, Switzerland: Centre for Development and Environment (CDE), University of Bern, with Bern Open Publishing (BOP).

Schuler R. 2004. Commercial Horticulture North-West of Mt. Kenya: A Sector Analysis with Emphasis on Implication of River Water Resources of the Upper Ewaso Ng'iro Basin [Master's thesis]. Bern, Switzerland: University of Bern.

Ulrich A, Speranza CI, Roden P, Kiteme B, Wiesmann U, Nüsser M. 2012. Small-scale farming in semi-arid areas: Livelihood dynamics between 1997 and 2010 in Laikipia, Kenya. Journal of Rural Studies 28(3): 241–251.

Ulrich A. 2014. Export-oriented horticultural production in Laikipia, Kenya: Assessing the implications for rural livelihoods. Sustainability 6(1): 336–347.

UNEP (2014), Africa Mountains Atlas. United Nations Environment Programme (UNEP), Nairobi.

Wiesmann, U., Kiteme, B., Mwangi, Z. 2016. Socio-Economic Atlas of Kenya: Depicting the National Population Census by County and Sub-Location. Second, revised edition. KNBS, Nairobi. CETRAD, Nanyuki. CDE, Bern.

Wiesmann, U., Kiteme, B., Mwangi, Z. 2014. Socio-Economic Atlas of Kenya: Depicting the National Population Census by County and Sub-Location. KNBS, Nairobi. CETRAD, Nanyuki. CDE, Bern.

Wiesmann U, Gichuki FN, Kiteme BP, Liniger H. 2000. Mitigating conflicts over scarce water resources in the highland–lowland system of Mt. Kenya. Mountain Research and Development 20(1): 10–15.

Wiesmann, U., Kiteme, B.P., 1998: Balancing Ecological Sustainability and Short-term Needs: A Regional Approach to Water Supply Planning. Eastern and Southern Africa Geographical Journal, Vol. 8, Special Number. 77-90.

Wiesmann, U., 1998: Sustainable Regional Development in Rural Africa: Conceptual Framework and Case Studies from Kenya. Geographica Bernensia, African Studies No. 14. Bern. 286 pp, 9 maps.

Zaehringer JG, Wambugu G, Kiteme B, Eckert S. 2018. How do large-scale agricultural investments affect land use and the environment on the western slopes of Mount Kenya? Empirical evidence based on small-scale farmers' perceptions and remote sensing. Journal of Environmental Management 213: 79–89.

Contributing Authors

CETRAD -
Centre for Training and Integrated Research in ASAL Development

Dr. Boniface Kiteme, Director/Senior Research Scientist (Lead: Overall coordination and lead-author)

Ongwae Samoka, RTD Deputy Director/Hydrogeologist

Jacinta W. Muchugu, Administration & Finance Manager

Grace N. Wambugu, Senior Research Assistant Socioeconomy

Emma Odera, Research Scientist-Environmental Management and Planning

Milton M. Muriungi, Research Assistant Hydromet Monitoring

John Mwangi, Research Scientist Water and Land Resources Management

Evanson Njuguna, Research Scientis/Head Knowledge Management and Land Use Planning (Responsible for design and refinement of maps)

James Wanjau, IT Manager

WRA - Water Resources Authority

Simon W. Wang'ombe, RTD Regional Manager ENNCA

Timothy M. Mutie, RTD Regional Manager ENNCA

Philip K. Munyua, ENNCA

Peter Ng'ang'a, ENNCA

Jacqueline N. Mboroki, ENNCA

ENNDA - Ewaso Ngiro North Development Authority

Eng. Josiah W. Mulwa (Lead: working group on Industrial Transformation Scenario)

CDE - Centre for Development and Environment

Prof. Urs Wiesmann (Lead: Conceptual framework, methodological approach, moderation of the workshops, and drafting of this report)

Senior Research Associates CETRAD

Prof. Japheth Onyando. Egerton University (Lead: working group on Agrarian Transformation Scenario)

Dr. Jeremiah Njeru, NRM/GIS/KM Specialist (Lead: working group on Peripheral Transformation Scenario)

Dr. Mordecai O. Ogada, Conservation Solutions Africa

Eng. Mike Thomas, Rural Focus Limited

Eng. J.M. Maina, Irrigation, Laikipia County

Ministry of Water & Sanitation and Irrigation

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Centre for Training and Integrated Research in ASAL Development
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