



# Towards Resilient Cities in Africa: The options of landscape based storm water management

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University



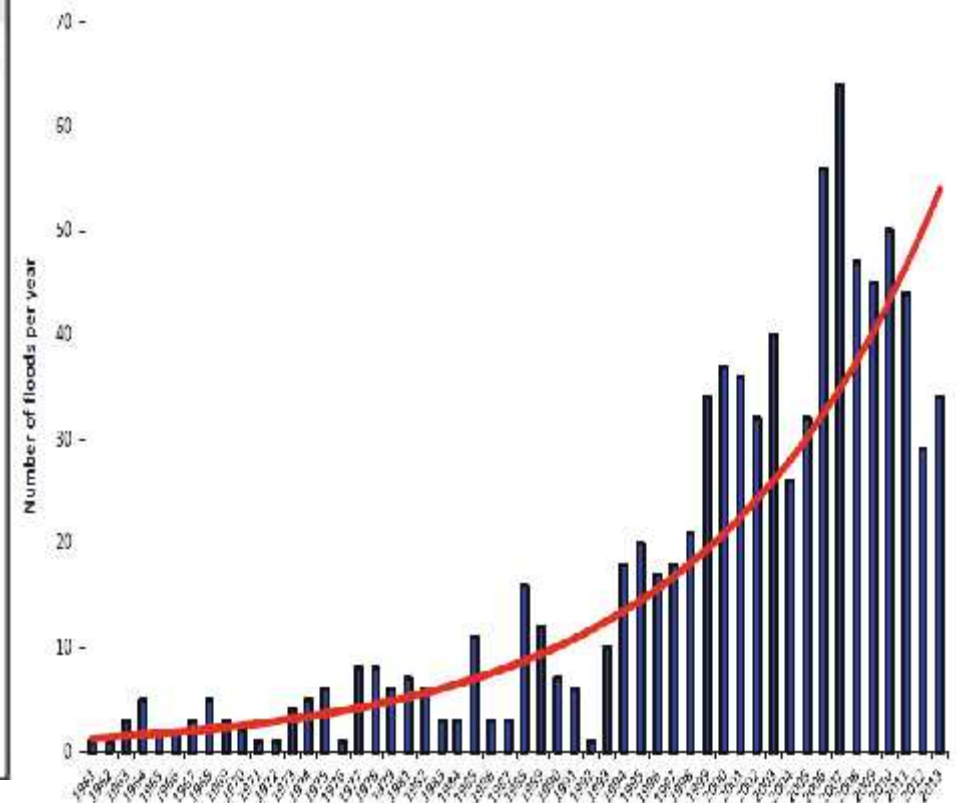
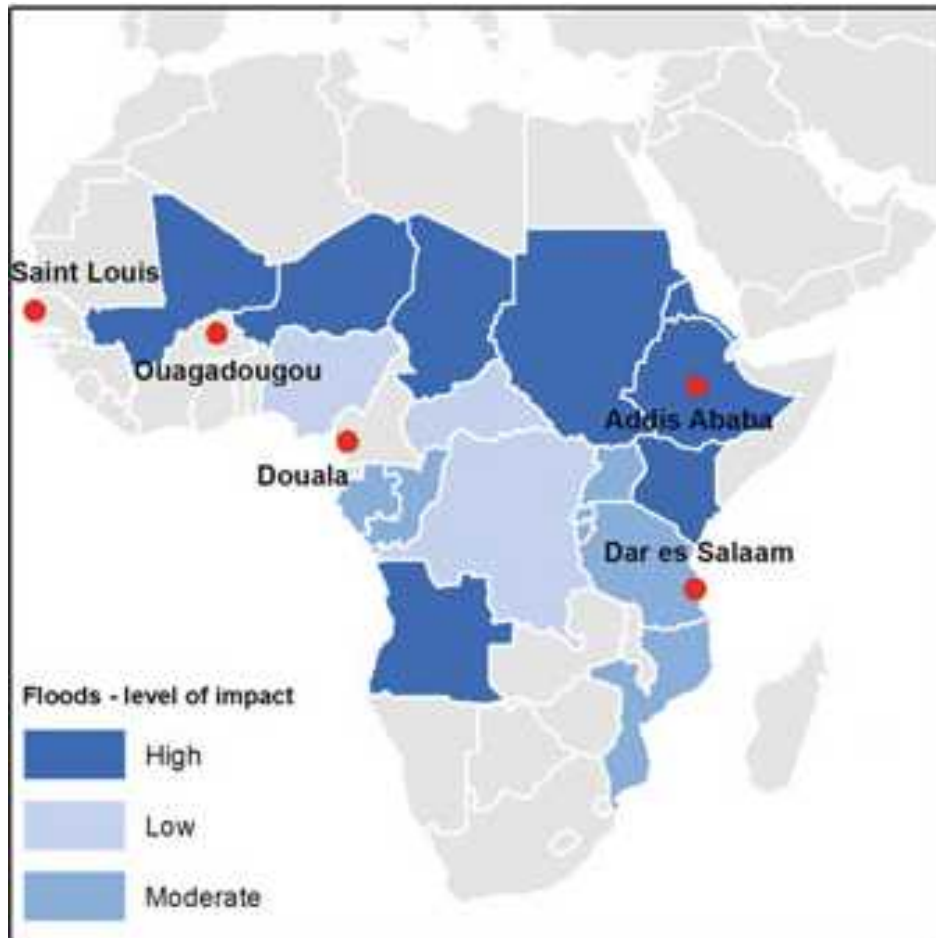
## Climate change and Urban Vulnerability in Africa

Assessing vulnerability of urban systems, population and goods in relation to climate induced disasters in Africa

2010-2013



# Flood



Pauleit et al 2015

Future City 4

S. Pauleit · A. Coly · S. Fohlmeister  
P. Gasparini · G. Jørgensen · S. Kabisch  
W. J. Kombe · S. Lindley  
I. Simonis · K. Yeshitela *Editors*

# Urban Vulnerability and Climate Change in Africa

A Multidisciplinary Approach

 Springer



## CLUVA recommendations for the development of climate resilient African cities

Making  
Climate  
information  
relevant to  
decision  
makers

Adapting  
built  
environment  
and lifeline

Promoting  
urban green  
infrastructure

Preventive  
action for  
reducing  
social  
vulnerability

Fostering  
climate  
change  
governance

Strengtheni  
ng strategic  
urban  
planning



# Water Resilient Green Cities in Africa

September 2013 – December 2017



**EiABC**

Ethiopian Institute of Architecture,  
Building Construction and City Development  
ወንጀል ማህበረ ሰነድ ለፍጥነት ለሕይወት ለሰላም  
Addis Ababa University  
የሰላም ማህበረ ሰነድ



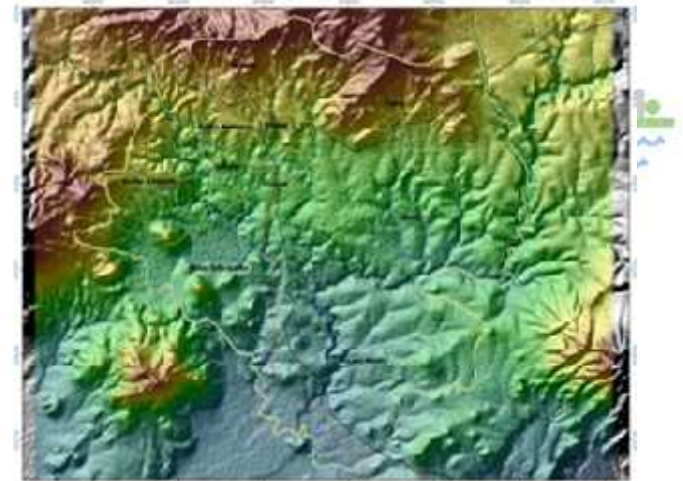
UNIVERSITY OF  
COPENHAGEN

**DANIDA**





# Case cities



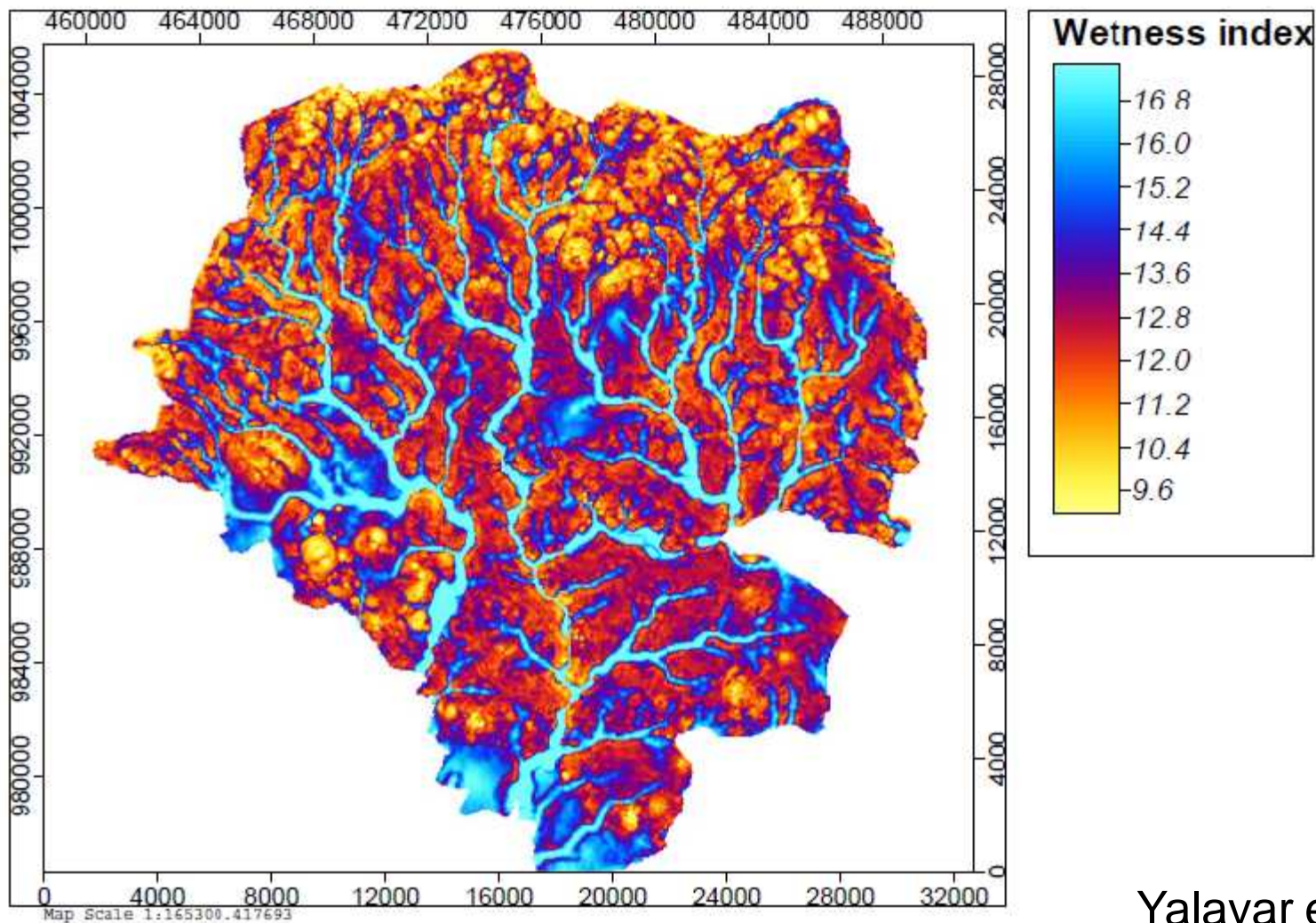
	Addis Ababa	Dar es Salaam
<b>Climate induced hazard</b>	Flood and drought	Flood, drought & sea level rise
<b>Climate projection</b>	Frequency of Extreme Rainfall Events expected to increase (CLUVA 2013)	Frequency of Extreme Rainfall Events expected to increase (CLUVA 2013)
<b>Stormwater</b>	Rainwater runoff expected to increase	Rainwater runoff expected to increase

# Flooding problem in Addis Ababa





## Flood prone area of Addis



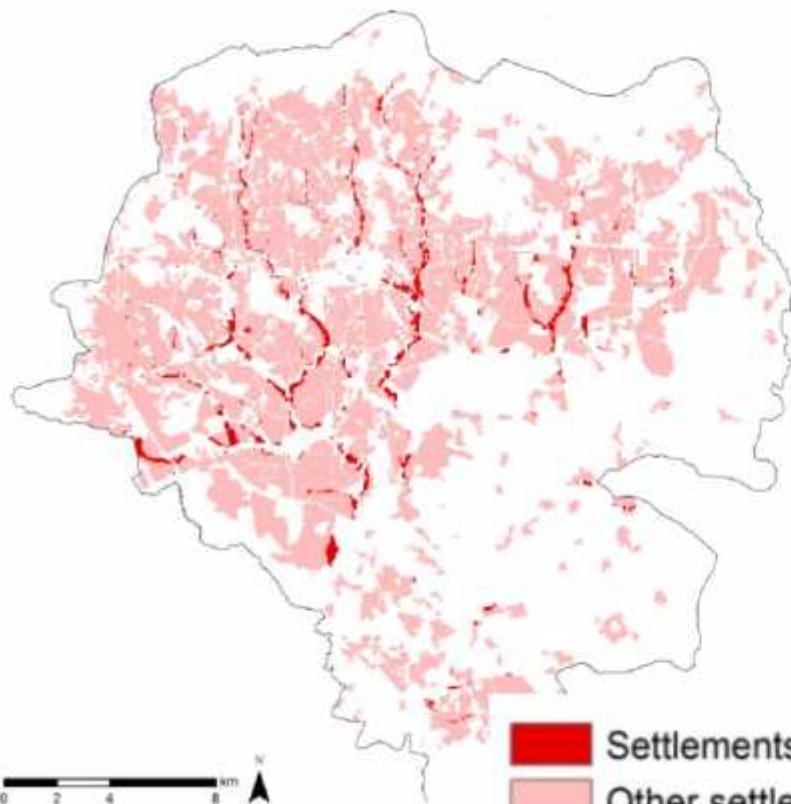
Yalayar et al. 2013



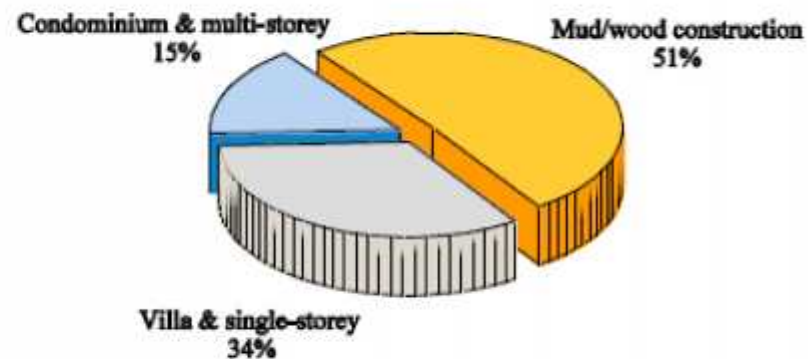
# EiABC

Disaster Institute of Cambodia  
Building Sustainable City Development  
to be Secure - ensure its around quality  
of life and security  
of its people

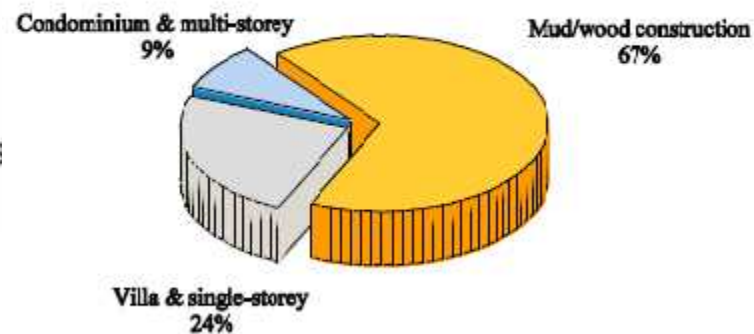
## Vulnerability of settlement and people to flood



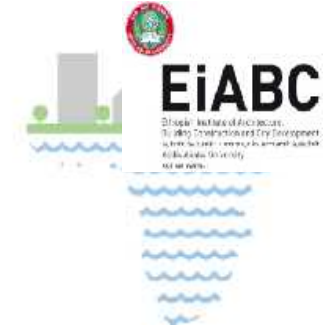
**Flood prone residential area**



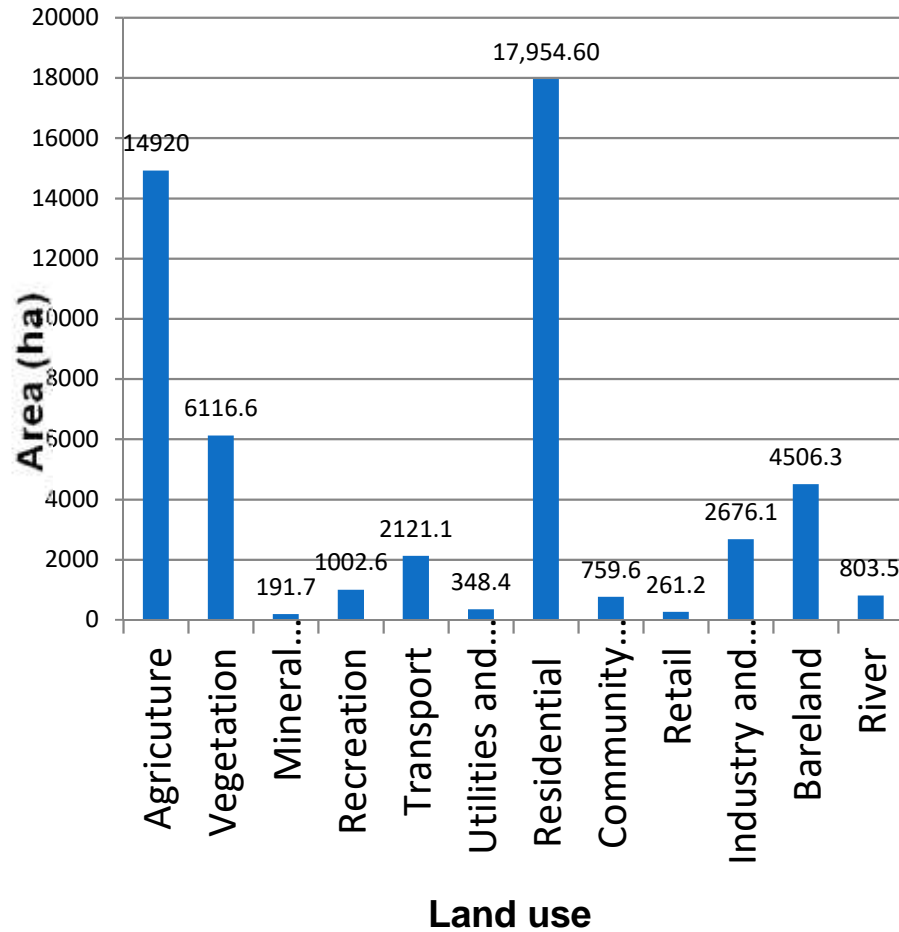
**People affected by flooding in the residential area**



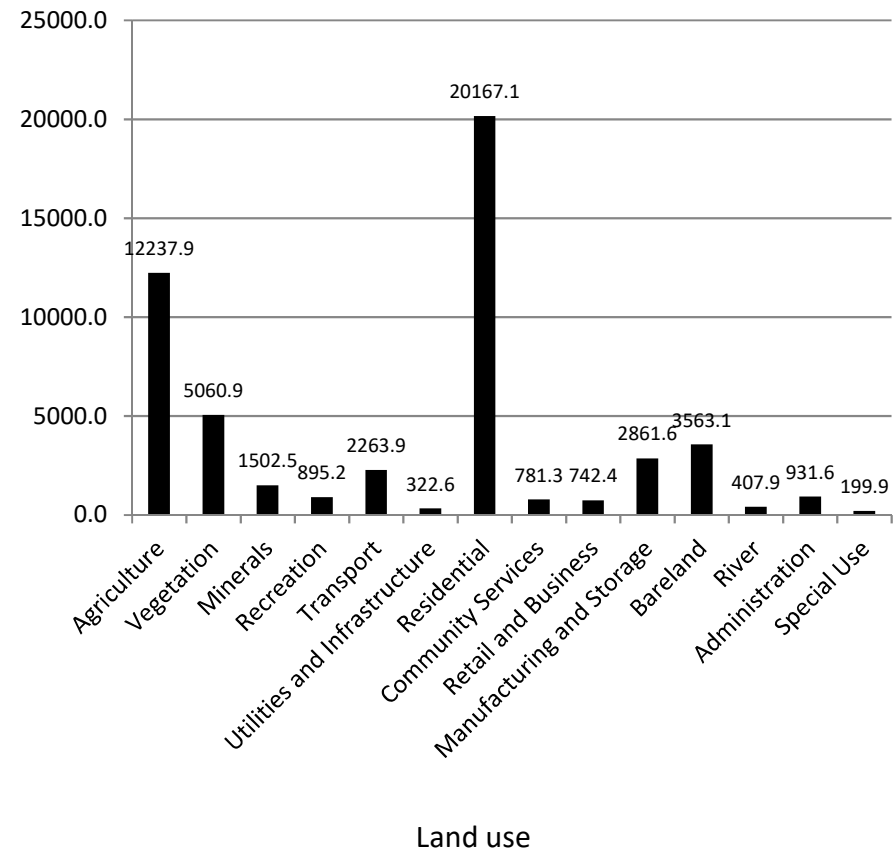
# Land use/land cover change



2006



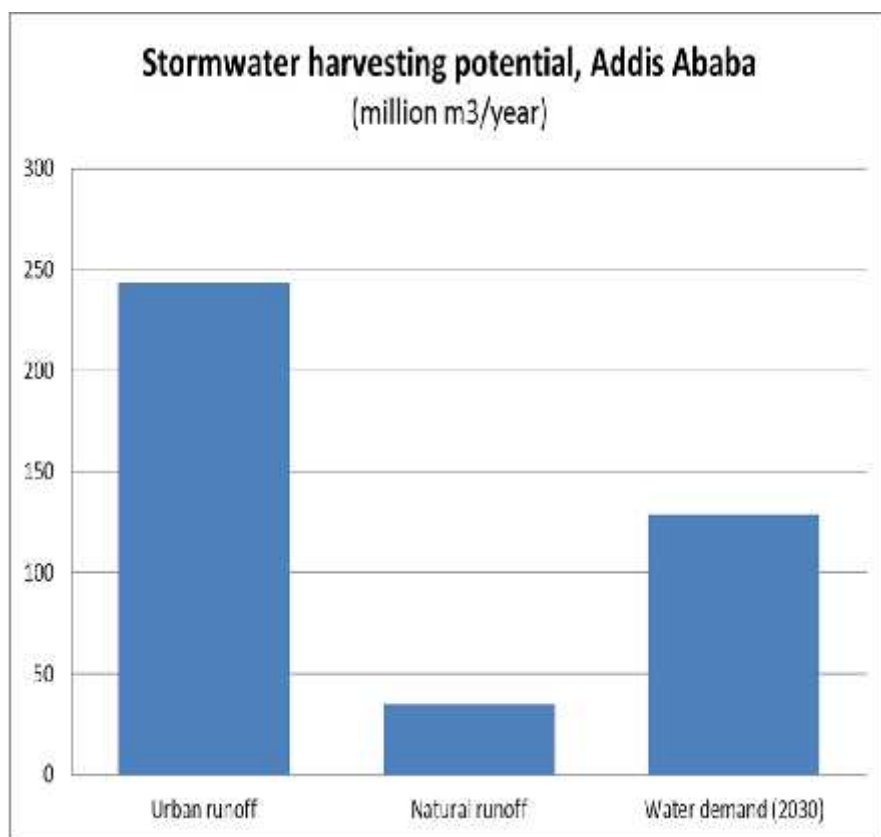
2016



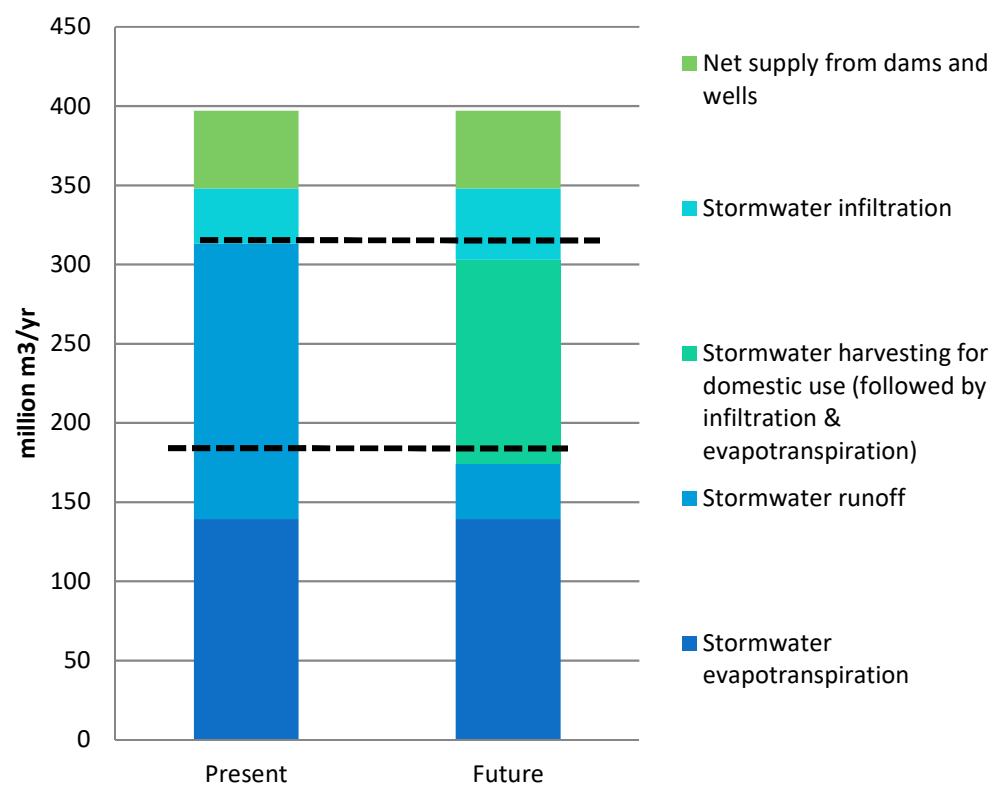


# Water scarcity





## Possible future water balance for Addis Ababa





# *Conventional stormwater management*

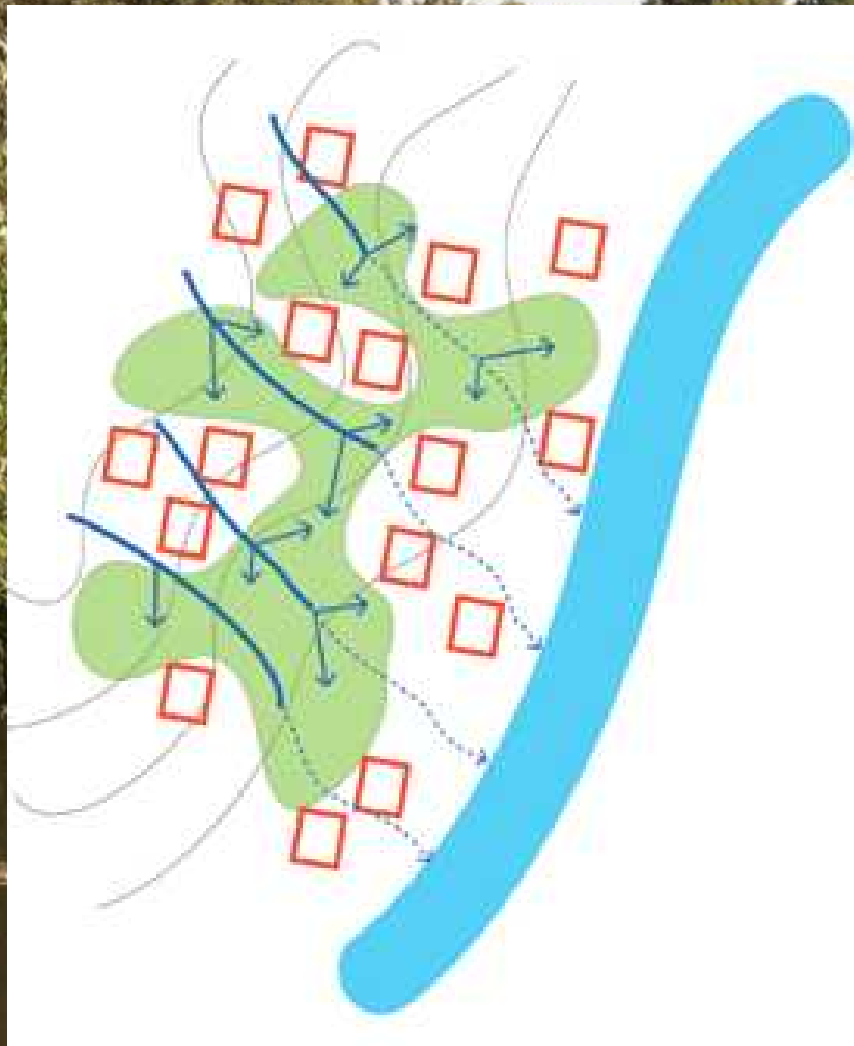
## PROBLEMS OF THE CONVENTIONAL APPROACH

- ☐ Increase in
  - run-off
  - erosion
  - siltation and
  - Flooding
- ☐ Causes pollution due to waste water and solid waste disposed in environment
- ☐ It is expensive
- ☐ Water a threat not a potential

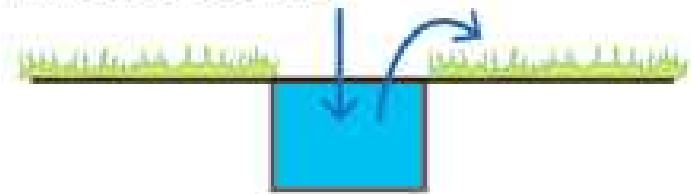


# Landscape based stormwater management

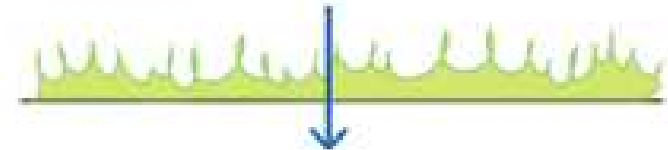
## Stormwater is a resource



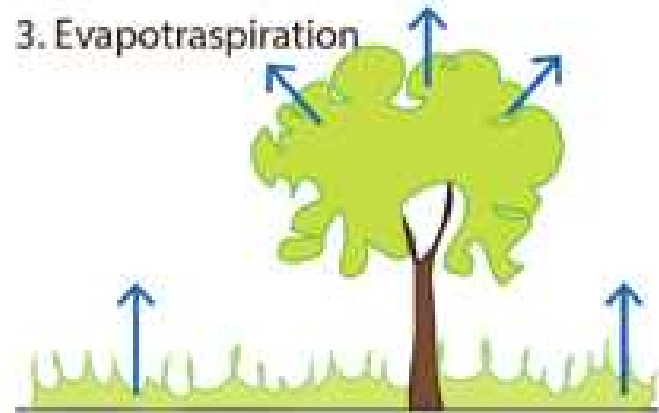
1. Reuse & retention



2. Infiltration



3. Evapotranspiration



# Project Hypothesis



## •African cities can leapfrog

Urban water resilience can be improved by establishing a strong **green infrastructure** that can

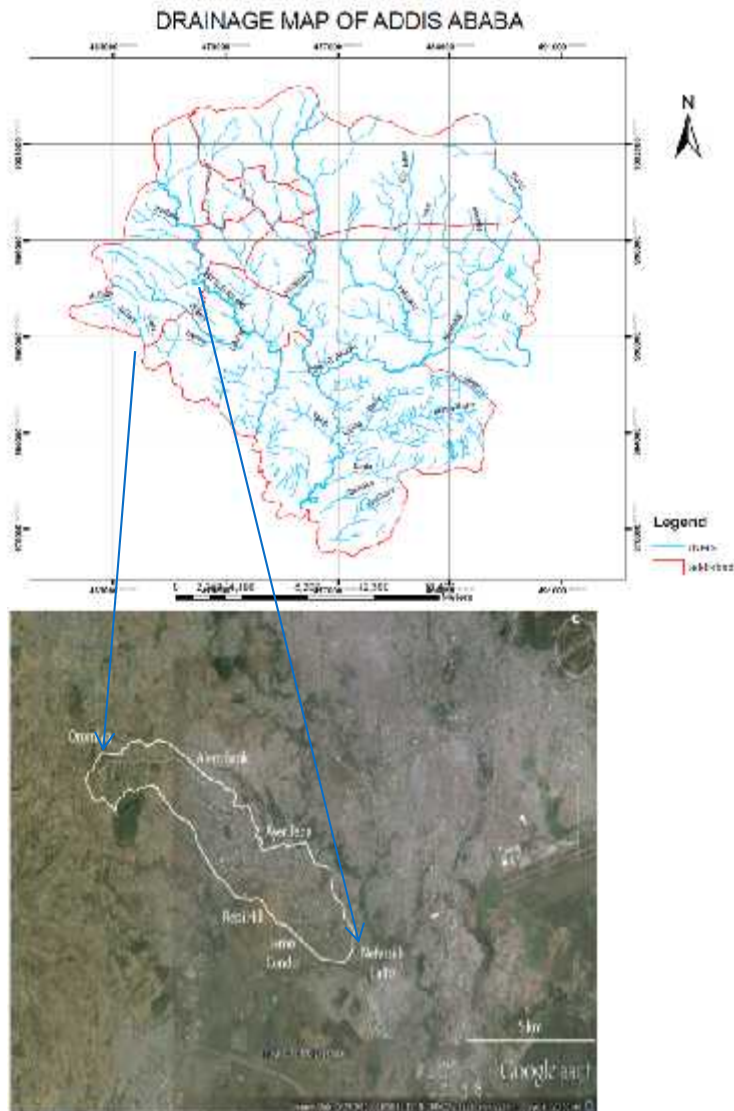
- reduce the impact of floods *and*
- provide day-to-day services to the citizens  
(such as water supply, food, open space)



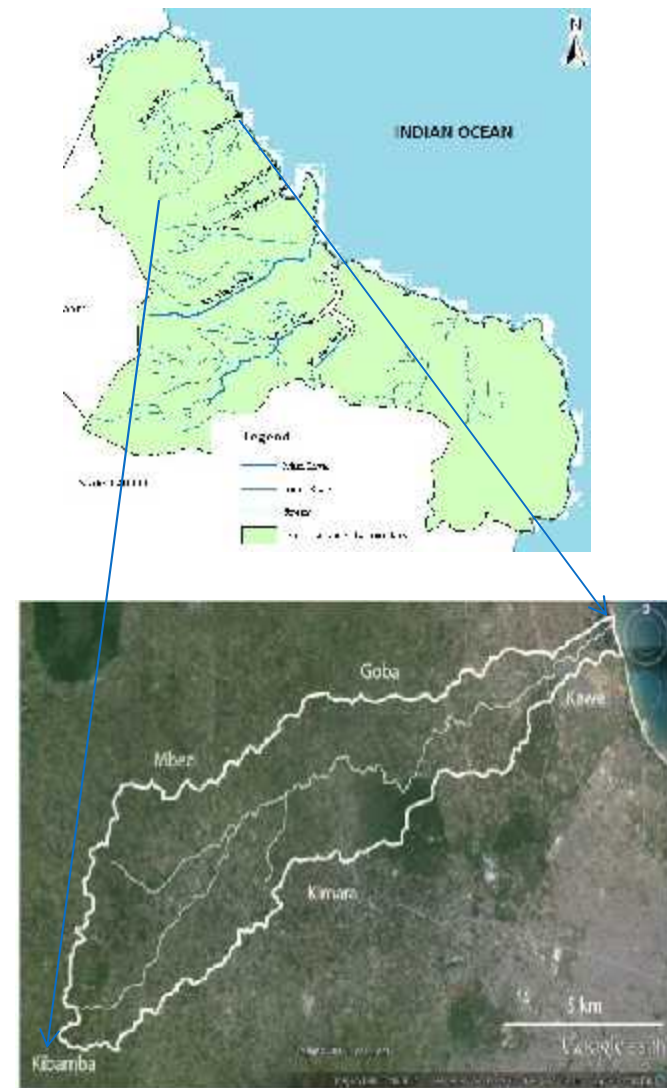
# Case study sites



## Jemo river catchment, Addis



## Mbezi river catchment, Dar



January 16, 2014



# Community design charrette



# Stakeholder interaction



- Three City level stakeholder workshops
- Two Local level stakeholder workshops
- Training to city experts on landscape based stormwater management and green infrastructure development
- FGD and Household survey





# Testing of 1:1 stormwater management pilot projects



## 1. Bio-retention system



## 2. Infiltration trench with tree pit



## 3. low-cost storm water filtration technology





**EiABC**

Ethiopian Institute of Architecture,  
Building Construction and City Development  
(EiABC), Addis Ababa University  
Addis Ababa, Ethiopia

## **LANDSCAPE BASED STORM WATER MANAGEMENT STRATEGY FOR JEMO RIVER CATCHMENT IN ADDIS ABABA**



**Ethiopian Institute of Architecture, Building  
Construction and City Development (EiABC), Addis  
Ababa University**

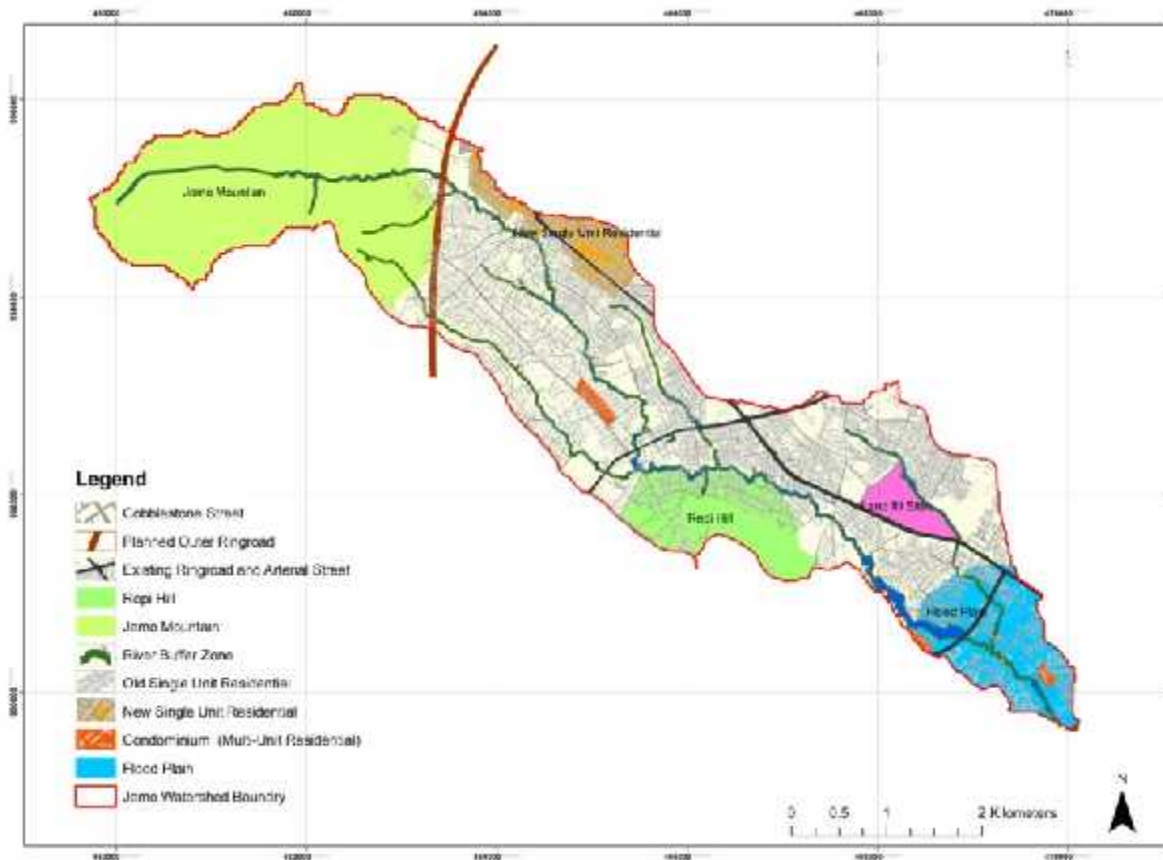
April 2017



**EiABC**

Environmental Impact Assessment  
Consulting  
100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000

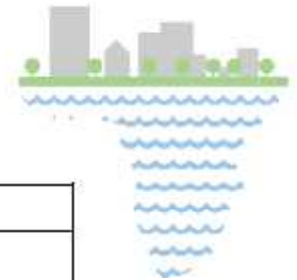
# Layered Retrofit Approach to improve water resilience at Jemo River catchment



1. Jemo Mountain
2. River buffer zone
3. Floodplain
4. Condominium residential
5. Single family residential (planned and unplanned)
6. Primary Arterial street
7. Cobble stone street
8. Repi Hill



# Proposed responsibility of actors for LSM



	<b>Institution</b>	<b>Expected activities related to LSM</b>
1	Addis Ababa Environmental Protection Authority	<ul style="list-style-type: none"> <li>• Provides regulatory framework, regulation and standard for catchment management plan</li> <li>• Awareness raising on catchment management</li> </ul>
2	Oromia Regional State and Addis Ababa City Government	<ul style="list-style-type: none"> <li>• Collaborate in Jemo mountain management and implementation of LSM measures on the mountain</li> </ul>
3	Addis Ababa City Roads Authority (AACRA)	<ul style="list-style-type: none"> <li>• Be involved in catchment management plan preparation</li> <li>• Implement different LSM measures on roads</li> </ul>
4	Addis Ababa River, River side and Climate change Project	<ul style="list-style-type: none"> <li>• Be involved in catchment management plan preparation</li> <li>• Delineate and maintain river buffers for stormwater management, pollution reduction and other benefits</li> </ul>
5	Beautification, Parks and Cemetery Development and Administration Agency	<ul style="list-style-type: none"> <li>• Be involved in catchment management plan preparation</li> <li>• Implement LSM measures on public parks, plaza and cemetery</li> </ul>
6	Addis Ababa Construction Bureau	<ul style="list-style-type: none"> <li>• Collaborate with communities in the implementation of LSM measures on local streets and communal green spaces</li> </ul>
7	Addis Ababa Water and Sewerage Authority	<ul style="list-style-type: none"> <li>• Implement reservoir watershed management</li> </ul>
8	Addis Ababa Urban Plan Institute	<ul style="list-style-type: none"> <li>• Integrate landscape based storm water management in the planning process</li> </ul>

# Activities and actors for implementing LSM measures at Jemo river catchment



N <sup>o</sup>	Land use/layer	LSM measure	Activities	Project strategies	Actors
1	Jemo mountain	Afforestation	<ul style="list-style-type: none"> <li>• Development and preparation of nursery site</li> </ul>	<ul style="list-style-type: none"> <li>• Identification of land holders and users</li> <li>• Awareness of community</li> <li>• Creating financing source</li> <li>• Support farmers financially</li> <li>• Social awareness, social cohesion</li> </ul>	<ul style="list-style-type: none"> <li>• Addis Ababa Environmental Protection Authority</li> <li>• Oromia Forest and Wildlife Authority</li> </ul>
			<ul style="list-style-type: none"> <li>• Mountain terracing and planting holes preparation</li> </ul>		<ul style="list-style-type: none"> <li>• Community, farmers, local administration</li> </ul>
			<ul style="list-style-type: none"> <li>• Transfer from the nursery to the mountain site</li> </ul>		<ul style="list-style-type: none"> <li>•</li> </ul>
		Storm water interceptor swale and dyke system		<ul style="list-style-type: none"> <li>• Training</li> </ul>	<ul style="list-style-type: none"> <li>• Addis Ababa Environmental Protection Authority</li> <li>• Addis Ababa Bureau of Construction</li> <li>• Addis Ababa Roads Authority</li> </ul>
2	River bufferzones	Setting buffer zones & flood plains	<ul style="list-style-type: none"> <li>• Piloting on specific river segment</li> <li>• Identification of properties &amp; land users of adjacent areas</li> <li>• Reconciliation of stakeholders' interests on river buffer zone setting</li> <li>• Setting rules laws and social arrangements</li> <li>• Participatory resettlement of residents living in the designated buffer zones</li> </ul>	<ul style="list-style-type: none"> <li>• Differentiated strategy for open field areas and settled areas</li> <li>• Select open areas for buffering pilot project</li> <li>• Seek community consent</li> <li>• Institutional leadership</li> <li>• Green&amp; health sensitization</li> <li>• Negotiation, cooperation &amp; formulation</li> <li>• Creating employment opportunities</li> </ul>	<ul style="list-style-type: none"> <li>• Addis Ababa Environmental Protection Authority</li> </ul>
		Vegetating river buffer with perennial and annual plants	<ul style="list-style-type: none"> <li>• Identification of vegetative types to be planted</li> <li>• Selecting specific locations for plantation</li> <li>• Identifying properties</li> </ul>		
		Storm water interceptor swales and dykes	<ul style="list-style-type: none"> <li>• Same as above</li> </ul>		



# LSM Strategy handover in Addis







THANK YOU FOR YOUR ATTENTION

# Acknowledgement



- The Danish Development Agency (DANIDA) is acknowledged for financing the WGA project