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Reducing the imperviousness of urban soils: a greener way of managing runoff that can be tricky to implement in Southern France

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1 **Reducing the imperviousness of urban soils: a greener way of**
2 **managing runoff that can be tricky to implement in Southern**
3 **France**

4 PREPRINT

5 **Abstract**

6 Urban pavements, which help to maintain streets clean and secure,
7 generate large amounts of runoff that aggravate flooding and degrade
8 the quality of surface water. In the context of ecological and climatic
9 crisis, they also contribute to creating heat islands in cities - as well as
10 hindering biodiversity. So greening cities must be encouraged.

11 Our article evokes the situation of Montpellier - Méditerranée
12 Metropolis (Montpellier 3M, Southern France) which is experiencing
13 one of the strongest demographic and urban growth in France. It
14 raises the question of the impact of increasing construction on the
15 quality of water in small and fragile coastal catchment areas by the
16 Mediterranean. It also questions local public policies in an attempt to
17 identify the brakes and levers on the greening actions for the effective
18 management of runoff water, encouraged by legislation: de-paving,
19 setting up rain gardens, returning to permeable urban soils as well as
20 encouraging the development of vegetated roofs.

21 To do so, we mobilise empirical material collected during a sociological
22 survey - in addition to hydrological and chemical measurements. Our
23 aim was to provide information on a wide range of stakeholders'
24 perspectives which is needed if blue-green infrastructure are to be

25 adapted to local contexts, so that they are both efficient and judged
26 as legitimate solutions (O'Donnell et al. 2021). Our reflection suggests
27 ways to democratically think about the dismantling of modern coating
28 infrastructures, to slow down urban water flows, and thus improve the
29 habitability of Southern European cities in a context of climate and
30 ecological crisis.

31 Keywords: hydrosociology; runoff ; water quality; urban greening ;
32 depaving

33

34 **Outline:**

35 Introduction

36 Case-Study, material and method

37 Results

38 -Concerns about floods come first

39 -The constraint of housing the new inhabitants.

40 -Confusion between mandatory compensation and depaving.

41 -Other obstacles and levers.

42 Discussion

43 Conclusion

44

45 « *The more we pave, the more we make soils impervious, the more*
46 *important the problem of water recovery and circulation is* ». Alain
47 Dupont, industrialist interviewed by the philosopher François
48 Dagognet, Cahiers de Médiologie, 1996.

49

50 **Introduction**

51 It is said that the King of France, Philippe Auguste, who was bothered
52 by the water and miasma that stagnated in the streets of Paris,
53 ordered their paving as early as the 12th century. Although various
54 materials and techniques were tested over time, responding to issues
55 of safety, durability of pavements (but also carriages) and hygiene, it
56 was not until 1838 that the first trials of bituminous coatings took
57 place - also in Paris (Holley 2003). Efforts in this field intensified after
58 the Second World War with the development of new, more resistant
59 bituminous mixes - based on hydrocarbons, minerals, and then
60 synthetic additives - with a background of strong demand from
61 automobile clubs for the development of road infrastructures
62 (Harismendy 1999).

63 The advantage of bitumen over other road surfaces (paving stones for
64 instance) is that it is less expensive and less noisy even in heavy traffic.
65 It is also binder, adhesive and waterproof, which means that it does
66 not slip too much when the road is wet. It was for all these reasons,
67 rather than to prevent the erection of barricades as during the student
68 demonstrations of 1968, that the Paris council decided, in 1976, to

69 cover its main boulevards with bitumen. Since then, most French
70 urban soils have been paved and made impervious (as well as some
71 roofs - for waterproofing reasons). Pedestrian or recreational areas,
72 such as schoolyards, are not exempt from bitumen. This is comparable
73 to the situation in the USA where 90% of pavements are bitumen
74 (Holley 2003).

75 However, the very qualities that have made bitumen such a modern
76 material, which makes it possible to walk or drive 'dry' in all weathers,
77 are posing new problems in the current ecological crisis (McGrane
78 2016). Not only does it accumulate heat during heatwaves, which are
79 exacerbated by climate change, but it deprives cities of much-needed
80 water in times of drought. It also encourages flooding by speeding up
81 the flow of rainwater into rivers. A lesser-known phenomenon, it also
82 allows pollutants carried from roadways, such as tyre residues and
83 hydrocarbons, to be washed out and concentrate in runoff (Rio 2019).
84 Thus, demographic growth and urban expansion, which go hand in
85 hand with massive soil imperviousness, are disrupting hydrological
86 and ecological cycles in cities at levels that are still very little studied -
87 even though compensatory measures, with less impact on
88 hydrological cycles, were made compulsory in France as early as 1990
89 for all new urbanisation projects (e.g. storm basins) and later with the
90 European Water Framework Directive (WFD).

91 In different parts of the world, voices are also raising in the
92 sustainability sciences and architecture to promote further less
93 harmful green-blue infrastructures (Ghofrani, Sposito, Faggian 2017;

94 Garda 2019; Pochodyla, Glinska-Lewczuk, Jaszczak 2021). This is the
95 case in China, where the idea of the sponge city has been widely
96 developed in response to the construction of new metropolises and
97 neighbourhoods (Guan, Wang, Xiao 2021). There are also citizens'
98 initiatives to 'depave' soils at the local level in Belgium following the
99 *General assembly of Water* in Brussels (Zitouni 2013) or in North
100 America, e.g. under the impetus of the NGOs *Depave Paradise* (USA
101 and English speaking Canada) and *Sous les pavés* (Québec). In France,
102 despite scientific recommendations and institutional incentives,
103 actions in this domain remain very limited. They are confined to
104 schoolyards and car parks under municipal ruling. This is particularly
105 true of Mediterranean towns, which have not only inherited an urban
106 history that is as long as it is mineral (old town centres) but are also
107 experiencing high demographic growth because of the attraction of
108 the sun and the coastline¹. We wanted to use a specific case study to
109 understand what could help or hinder the adoption of greener
110 solutions in these specific regions - compared with what is being done
111 further North, for instance in Portland (USA), Rotterdam (The
112 Netherlands) or Newcastle (UK) - see O'Donnell et al. 2021.

113 Our paper reports on interdisciplinary research conducted on the
114 quality of runoff washing the impervious areas of Montpellier
115 Méditerranée Metropolis (Montpellier 3M), in the South of France,
116 and on the technical and social obstacles as well as levers to the

¹ The coastline explains why many Mediterranean cities have, for a very long time, been more oriented towards the sea than towards their inner streams and rivers. This is the case of Montpellier, Marseille and Perpignan (Romain 2014).

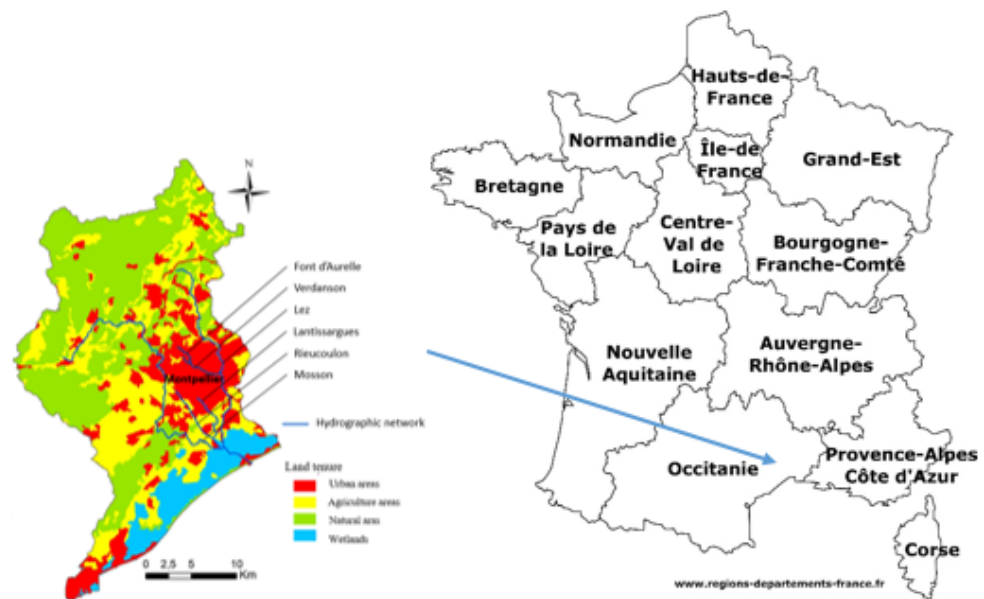
117 adoption of urban greening methods that help runoff infiltration. This
118 multidisciplinary research shed light on debates that will undoubtedly
119 intensify in the future with the recurrence of extreme climatic events,
120 particularly in the Mediterranean context. Our objective is to complete
121 the range of hydrosociological research (Wesselink, Kooy, Warner
122 2017), rather focused on quantity issues (flooding or drought), to
123 reconnect urban hydrology issues with water quality issues, land
124 occupation, planning and social practices that condition the future of
125 the water cycle in cities.

126

127 **1. Case-Study, material and method**

128 Montpellier 3M, located in the South of France on the Mediterranean
129 coast, is a very attractive urban area. Composed of 31 municipalities
130 (including Montpellier city), it has 427,500 inhabitants, with an annual
131 growth rate of over 1% (slightly down in recent years), which is double
132 that of comparable metropolises, according to the French National
133 Institute for Statistics (INSEE, 2019). While Montpellier city itself
134 concentrates two-thirds of the population, it should be noted that the
135 outlying municipalities, such as *Juvignac* and *Le Crès*, experienced a
136 much more exceptional growth rate of 4% over the period 2006-2011
137 (INSEE 2019). The national authorities note that between 2009 and
138 2018, an average of 33 million square metres of land were artificially
139 developed in the region - mainly to build homes (DREAL 2020).

140



141

142 Map of Montpellier 3M and its rivers and streams (Source : Rio 2020)

143

144 Although all new buildings built in recent decades should, in principle,
 145 be connected to a separate sewer system, it should be noted that this
 146 is not the case in the older town centre. So 7% of homes are connected
 147 to the historic combined sewer system (Montpellier city). Part of the
 148 rainwater therefore goes to the metropolitan wastewater treatment
 149 plants, of which the main one, *Maera*, is under public control since
 150 2023. This plant is currently being renovated. Its treatment capacity
 151 has to be increased as it is still sufficient in normal times (despite the
 152 rapid growth of the population) and overflows with untreated water
 153 during rainy episodes of a month's return period.

154 Furthermore, the six rivers crossing Montpellier 3M urban area (*Font*
 155 *d'Aurelle*, *Verdanson*, *Lez*, *Lantissargues*, *Rieucoulon* and *Mosson* - see

156 map above) do not have the same flow rates nor the same carrying
157 capacity. While the *Lez* and *Mosson* rivers, the largest ones, enjoy a
158 privileged status and retain part of their natural course, although lined
159 with old and new hydraulic works, the bed of the *Verdanson*, as it flows
160 through the city, has been partly sealed by concrete and even covered
161 for some reaches. It is a favourite place for street artists and skaters
162 who play along its banks during its long dry periods. The smallest rivers
163 *Font d'Aurelle*, *Lantissargues* and *Rieucoulon* have either been
164 culverted, walled up or simply made invisible. They occasionally
165 reappear during intense storms, which cause them to burst their
166 banks, forcing the closure of certain traffic routes. For instance, for the
167 period 1994-2018 the inter-annual rainfall in Montpellier area was 669
168 mm (from 320 to 1149 mm - SD 199 mm) with 97 rainy days on
169 average. However, there is a preponderance of light or heavy rainfall,
170 with an increase in the intensity of extreme events over the recent
171 period, which do not favour infiltration and the filling of the soil and
172 subsoil with water.

173 These specific features motivated our questioning on the impact of the
174 increasing artificialisation on the quality of the runoff that reaches the
175 local rivers, especially as a significant part of the artificialised surfaces
176 are also made impervious. We know that building materials and road
177 coatings alter the natural water cycle in the city, some more than
178 others. Rain is indeed a problem for modern urban areas where
179 everything has been done to get rid of runoff as quickly as possible via
180 a complex network of gullies, drains and pipes - first to clean up the
181 city in the interests of health and safety. Let's remember that in the

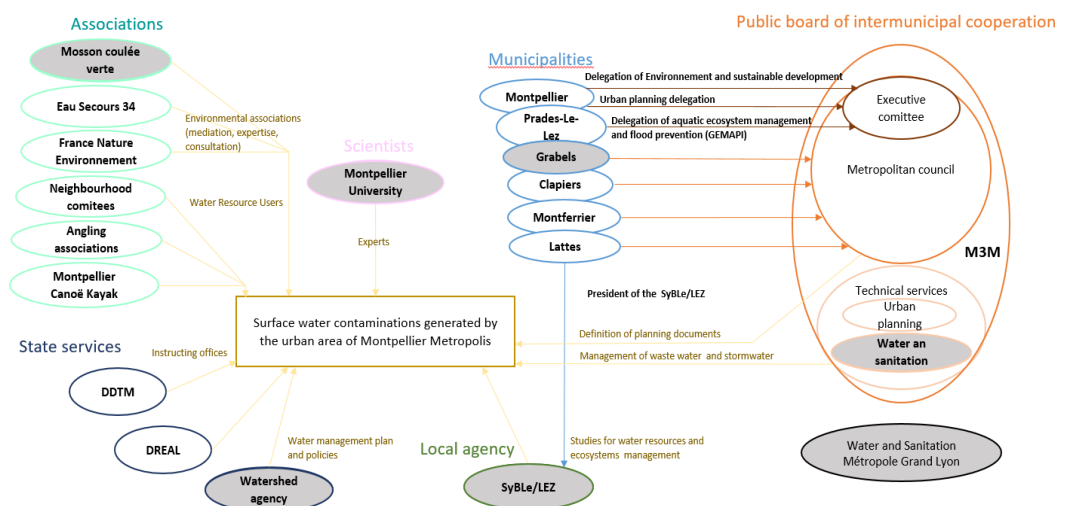
182 1830s, Montpellier city was twice hit by cholera epidemics – with the
183 consequence that it was one of the first French city to implement a
184 sewage system (Jeanjean 2020). At the same time, the impacts of
185 these infrastructural changes have been little studied. Some
186 researchers have focused on drinking and wastewater management
187 infrastructure, while others have focused on the natural urban water
188 cycle. The two types of approach remain poorly articulated - and not
189 very interested in runoff issues. However, it is now known that this
190 way of dealing with rainwater in the city, accelerating its
191 transformation into runoff that we will try to get rid of, has major
192 consequences (McGrane 2016). Each intervention on the soil has an
193 impact on its capacity to capture or store rain, necessarily increasing
194 the risk of flooding in the case of widespread impervious areas.
195 Beyond these quantitative problems, numerous data now make it
196 possible to assess the impacts on water quality. Intense runoff
197 enhances the washing out of the contaminants present in the urban
198 space, from pesticides to hydrocarbons, metal residues and synthetic
199 compounds, increasing the stormwater pollution before it reaches the
200 natural environment. In Montpellier city, Rio (2020) reported large
201 quantities of bacteria indicative of faecal contamination, metallic trace
202 elements such as zinc and copper, but also organotins and PAHs in high
203 quantities, above the environmental quality standards for some,
204 during high water periods (compared to low water periods), more
205 particularly in the *Verdanson* river (Rio, 2019). Aujoulat et al. (2021)
206 also pointed out several drug residues downstream from the city's
207 hospitals, the largest of which are built on the *very* same catchment.

208 Rio's thesis work (2020) consisted of hydrological and chemical
209 measurements, seeking to understand the risks that urbanisation,
210 coupled with soil artificialisation and imperviousness, posed to the
211 quality of surface water, particularly the vulnerable and remarkable
212 lagoons and wetlands located on the coast downstream from
213 Montpellier 3M. She completed her work with a sociological survey.
214 The aim was to anchor the models to be built in the field so that they
215 could provide relevant information about a given situation – in
216 response to critiques which often target the off-ground nature and
217 normativity of many models (Viveiros de Castro 2019). This took place
218 in two stages - in the framework of a collective approach. 24 long semi-
219 directive interviews were conducted, first with scientists and
220 institutional actors (State services, managers, municipal officials, and
221 technical services) in charge of water in the Metropolis, then with
222 sports and environmental associations and neighbourhood
223 committees. The aim was double: (1) to gather information on urban
224 planning and soil artificialisation, on runoff management techniques
225 in terms of their performances in reducing runoff volume and
226 improving stormwater quality, (2) to design local scenarios of urban
227 development which would be used as input data in the models of
228 urban hydrology to predict the level of stormwater quality according
229 to the evolution of land uses.

230 The interviews, which lasted between 30 minutes and two hours, were
231 all transcribed word by word before being coded and analysed in
232 relation to the different themes identified during the survey, namely
233 the degree of knowledge of the stakes of runoff and then of the quality

234 of water in connection with runoff, the sensitivity to the risk of
 235 flooding, the role of territorial planning tools, the capacity to define
 236 alternative greening techniques, the interest for new practices in this
 237 matter, according to the constraints, and the key-elements to be taken
 238 into account in the construction of possible contrasting scenarios of
 239 territorial development. All of this, in relation to the sociological
 240 profile of the interviewees. This work was followed by the organisation
 241 of a focus group or collective interview which allowed the project team
 242 to present its hydrological, chemical, and sociological results for
 243 discussion. An external professional, in charge of the urban greening
 244 policy in Lyon, another pioneering metropolis in this field, was also
 245 invited to provide points of comparison.

246
 247



248

249 Table 1: List of interviewees with their relation to the issue to be
250 addressed. The actors outlined in grey took part in the focus group
251 (Source: Rio 2020)

252

253 The event, which took place on 12 June 2019 over a period of 3 hours,
254 brought together 4 scientists (the authors of this article) and 8
255 stakeholders from the region, including representatives of the Rhone-
256 Mediterranean-Corsica Water Agency (RMC WA), the local river
257 management board, an elected official, and a member of a citizen
258 association. The participation rate was lower than expected. 20 people
259 had initially been invited (some had been interviewed and yet had
260 expressed interest) but due to unavailability and other pressing
261 matters, they did not all show up. We took this into account in our
262 analyses. The focus group was filmed, reviewed, and also discussed by
263 the authors. This enabled us to validate some of our hypotheses,
264 forged after the initial interviews and field observations, while
265 nuancing others.

266 Unlike quantitative methods, qualitative surveys do not derive their
267 scientific validity from the number of interviews conducted or the
268 representative nature of their samples. The aim is not to produce
269 statistics, but rather to analyse the content of the discourse of the
270 actors encountered by comparing them. In this case, the diversity of
271 the profiles of the interviewees is a better guarantee of quality.
272 Samples such as ours are composed according to the themes dealt
273 with. It is necessary to target the social actors concerned, for example,

274 representatives of administrations, professionals, and associations in
275 the field, and then to proceed by the snowball technique to identify
276 other people likely to bring complementary or contrasting points of
277 view. The sample is complete when a saturation effect occurs: the
278 discourses end up overlapping - or else, as happened to us, when the
279 people declare that they are unfamiliar with the subject under
280 investigation and are not able to discuss it. The analysis can therefore
281 begin based on the transcribed and coded interviews, but also of the
282 observations recorded during the survey. The aim is to make sense of
283 the testimonies in order to reconstruct the viewpoints of the actors -
284 which are characterised and illustrated through the presentation of
285 selected quotes. We proceeded in this way, inductively, to draw from
286 our data and their triangulation some arguments presented below.

287

288 2. Results

289 a- Concerns about floods come first

290 As explained here above, Montpellier 3M is subject to rare, but intense
291 and violent rainfall events called *Cévenol* episodes since they occur on
292 the foothills of the *Massif Central*, at the edge of the Mediterranean
293 (Jacques 2016). They usually happen in autumn and are caused by
294 vortices of different altitudes, followed by upward but stationary
295 motions that cause large rainfall heights in a short time (more than
296 100 mm in less than half a day). Even if the metropolis did not
297 experience the same catastrophic flooding problems as Nimes in

298 October 1988, we underline that it suffers quite regularly from floods
299 of its main rivers swollen by abundant rainfall. This is notably what
300 happened in September 2014, when 260 mm of rain fell in 4 hours
301 (Bouvier et al., 2018). This exceptional event, of a centennial type,
302 generated significant damage. Roads were cut off and thousands of
303 people had to be evacuated.

304 In this context, it is not surprising that the persons we interviewed,
305 especially those who were in decision-making positions at the time of
306 this major *Cévenol* episode, stated that flooding was their main
307 concern. An elected official from a small commune of the Metropole,
308 for example, stated:

309 *"Floods, we have them every year. It's something you live and feel, not*
310 *something you see in a schoolbook or that is explained to you... We*
311 *have all had to deal with floods at some point".*

312 This quote shows that we are both in the register of familiarity with
313 the event, which confers a certain experience, and the emotional.
314 Heavy or even extreme rainfall recurs periodically. Elected officials are
315 inevitably confronted with their consequences. They are responsible
316 for ensuring the safety of their constituents, in coordination with the
317 public emergency services, in the event of a weather warning. They
318 are also the ones who organise, after the event, the aid and the
319 restoration of local infrastructures - and request recognition of the
320 state of natural disaster to obtain financial and technical support. This
321 emergency character, with damage to property and persons, explains

322 why flooding is given priority. The consequence is that water quality
323 problems, which are less acute, take second place. Moreover, their
324 chronicity makes them less immediately perceptible (Erikson 1994).
325 Their effects are often deferred in time within a perimeter that is
326 difficult to delimit - unlike floods. Everything contributes to delaying
327 their inclusion on the political agenda.

328 Another elected official confirmed that "*when you deal with floods,*
329 *you don't deal with water quality*". Both for reasons of mandate, but
330 also for lack of time and concern. As Comby et al. (2019) explained
331 about the Lyon Metropolis, the presence of micropollutants in runoff
332 is not identified as an environmental or health problem neither by the
333 elected officials nor by the municipality technical services. In
334 Montpellier, the management of runoff itself, to limit overflow and
335 flooding, has only started to be considered seriously after the 2014
336 event as the same technical services had to work on a Flood
337 prevention plan – and still few respondents, especially among elected
338 officials and the public, believe that urban runoff and overflow from
339 stormwater systems is the cause of flooding in areas far from rivers.
340 As far as the inhabitants are concerned, they are not informed at all
341 about quality issues. They are concerned about the risk of flooding,
342 originating from rivers, and its immediately perceptible emergency
343 character. There is no clear social demand on qualitative issues - apart
344 from pressure from a few associations with an expertise in this
345 domain.

346 A regional representative of the RMC WA confirms this focus on
347 flooding, which prevents other urban water problems from being
348 considered and taken care of, with perspective. This is particularly the
349 case in Montpellier where the *Verdanson* bed in the city centre is
350 concrete or masonry – and sometimes entirely covered. After the
351 2014 floods, some of these structures were washed away, but they
352 were quickly reinstalled. Without legal constraints or political support,
353 the incentives to green the city by national institutions such as the
354 French biodiversity agency (OFB) and the RMC WA have little effect.
355 The alternatives, for managing runoff, are overshadowed by
356 considerations in terms of securing the city against flooding, which
357 borrow from the modernist register of rapid water drainage and
358 protection by dykes, all the more so since the legislation in this area is
359 not binding, especially for already developed areas. This has been
360 confirmed to us on many occasions by the managers in charge of
361 water and aquatic environments in the catchment area of the *Lez-*
362 *Mosson* rivers – as shown below.

363 *“So, the regional water management plan says things but does not*
364 *impose them. For new facilities, it can make requests, but to go back*
365 *to the existing, that's another thing! We tried to instil these ideas in the*
366 *Territorial Coherence Scheme (SCOT - a land planning document that*
367 *commits local authorities – authors’ comment), but each time we were*
368 *shut down. Today, the Metropolis is about flooding. That's all we see.*
369 *It should change its vision and open up... But it's not necessarily easy”!*

370 The consequence is that change depends mostly on the goodwill of
371 local political actors, who also face pressing demands for
372 accommodating newcomers.

373

374 b- The constraint of housing inhabitants.

375 The tone is much more critical when the representatives of angling
376 and environmental associations are questioned. They castigate local
377 urban policies that maintain “unsustainable” urban growth, which
378 leads to new constructions. For citizens with expert knowledge of
379 water and aquatic environments, there is both an inconsistency
380 between the prioritisation of flooding problems and the numerous
381 authorisations given to developers to build and extend the Montpellier
382 3M – as expressed by a local fisher – representative of an association
383 in charge of the protection of aquatic environments.

384 *“On the one hand, we fight against floods and on the other*
385 *hand, we do nothing to fight upstream, by preventing the*
386 *extension of impervious soils...” (angler).*

387 This contradiction has several origins. First of all, it stems from the
388 desire to make Montpellier 3M grow to rank among the main French
389 metropolises - a policy that was notably deployed under the
390 municipality of Georges Frêche (in office from 1977 to 2004) with
391 several major urban planning projects, for example, the central
392 Antigone neighbourhood (1980’s). The attractiveness of the

393 metropolis, located very close to the Mediterranean seashore, makes
394 its elected officials proud because it gives them power and prestige.
395 They maintain it at the same time as well as they carry its burden
396 because it forces them to complete the range of public facilities and
397 services available. As demographic pressure remains high, it is
398 necessary to reduce the pressure on the real estate supply by
399 launching new construction programmes in neighbourhoods that
400 replace wooded areas (*Malbosc* neighbourhood in the North – 2000's)
401 and wetlands (*Grisette-Ovalie* and *Port Marianne* neighbourhoods in
402 the South – 2010's and 2020's). Recently, demographic growth has
403 been particularly strong in the smaller towns of the Montpellier 3M,
404 which have launched their own urban development programmes,
405 leading to the construction of further new neighbourhoods with
406 blocks of flats and villas.

407 For some associative actors, as shown below, the causes of this rush
408 are not only attributable to elected officials focussing on the need to
409 house families of newcomers in the Montpellier city and the
410 surrounding municipalities, but also to outdated ways of seeing and
411 analysing the situation, particularly within the technical services,
412 which engineers could not be aware of the new methods and
413 techniques of green urban planning.

414 *"The problem is the discrepancy between the display and, I would say,*
415 *the will of the municipality services. And then the will of the elected*
416 *representatives! There is a gulf. In other words, the elected officials are*
417 *not ready... Have you seen the new districts how they are made? It's all*

418 *mineral. The city is completely mineralised. They reproduce Paris with*
419 *its pavements. Its concrete... In the law, it is clearly stated that they*
420 *must preserve the landscape... Urbanisation that considers the*
421 *wetlands and preserves their functionalities, including protection*
422 *against flooding... But, not at all! In fact, their objective is to fit people*
423 *in somewhere and then that's it. In their minds, they must solve the*
424 *problem of housing people and then they'll see... Instead of avoiding*
425 *paving directly... The problem we encounter is the upgrading of*
426 *officials who date and never question themselves. ”.*

427 The recent controversy over the construction of the new *Mogère* train
428 station in a flood zone in the South of Montpellier 3M - a former
429 agricultural area, has fuelled mistrust. The associations that proposed
430 other developments (for instance the extension of the existing station
431 in the city centre), more respectful of the natural constraints of the
432 site and of biodiversity, but were not heard, expressed a certain
433 amount of anger at the time of our investigation. According to them,
434 runoff issues are not handled efficiently – although they can generate
435 more damage than overflowing rivers. The Metropolis' planning
436 choices, which favour urban sprawl, artificialisation and the paving of
437 new areas, are denounced. Whether on the part of the elected
438 officials, these claims are swept aside in view of the social and
439 economic issues at stake. Bad choices are systematically attributed to
440 the political majorities previously in place. On the contrary, they
441 underline efforts to create new green spaces in the city.

442

443 c- Confusion between mandatory compensation and depaving.

444 However, our questions on the urban growth of the Montpellier 3M
445 and the resulting problems on runoff and water quality have provoked
446 many reactions. The elected officials and public service engineers
447 know what the legal requirements are. They quoted the prescriptions
448 intended to retain rainwater on the plots. Among these prescriptions,
449 included in the local urban development plan, is, for instance, a
450 maximum imperviousness coefficient that varies according to the
451 sectors at stake, applicable to new constructions or building
452 extensions. It also applies to demands for individual building permits,
453 as explained by an elected official of a city located North of
454 Montpellier 3M.

455 *“In the case of building permits, it is ensured that there is a certain*
456 *percentage of soil surface that remains pervious. I don't know if it's 20*
457 *or 25% of the plot, you can find it there in the regulations... at least*
458 *25% of the plot that must not be concreted, paved, or built on, of*
459 *course. This is precisely to ensure a certain permeability”.*

460 In any case, as soon as the size of the impervious surfaces are changed,
461 compensatory measures are planned to limit runoff. In addition to
462 dykes (which are protection measures but not compensation ones),
463 the interviewees cited the storm basins and ditches of which they
464 were aware or which they have specifically worked on. A
465 representative of a neighbourhood association even stated:

466 *“When Georges Frêche took over the region, that's when they started*
467 *making retention basins and protection dykes”*
468 *(RepresNeighbourColl1).*

469 These compensatory infrastructures have been legally mandatory
470 since 1992 for any new construction project. The oldest are mostly
471 fenced off and closed to the public. The most recent are immediately
472 noticeable in the new neighbourhoods of the metropolis, where they
473 are intertwined with the buildings. They are now designed as green
474 spaces, likely to store rainwater and to offer additional amenities to
475 city dwellers (they can be turned into dog runs, children’s playgrounds,
476 or sports fields, for instance). Elected officials are often proud to cite
477 these achievements as the example below illustrates.

478 *“We created an open storm basin for retaining water which can be*
479 *used as a playground. It's planted with trees. When it rains, water is*
480 *stored. This is a good example of a construction in the city center made*
481 *for perviousness ».*

482 Without constituting depaving actions, retention basins and ditches
483 are spontaneously associated with “policies in favour of
484 perviousness”, since they help to avoid too much concrete or bitumen
485 in the city and may favour infiltration of runoff. Consequently, some
486 elected representatives argued that they had already “*done a lot to*
487 *limit imperviousness”* by complying strictly with the regulations. Their
488 knowledge of alternative or greener rainwater management
489 techniques seems to be limited. There was even a certain amount of
490 confusion regarding the available options and their capacities. The

491 other infrastructures most frequently cited, apart from storm basins
492 and ditches, were public parks, vegetated roofs being unanimously
493 dismissed as unsuitable to the Mediterranean climate. The quote from
494 an elected official below is evidence of this. *“We have a motto, it's a*
495 *development zone (ZAC in French- authors' note), a park. This is what*
496 *we do everywhere, what we did at the former military school, what we*
497 *did at the new St Roch neighbourhood, what we're going to do at*
498 *Cambaceres [...] it's obviously to preserve everything that is... And for*
499 *rainwater, each time, we calculate on each ZAC: first we make the*
500 *networks, we plant, and we create retention basins. That's what's*
501 *important!”*

502 This orientation is confirmed by the technical services of the
503 metropolis. Like engineers and technicians of government agencies,
504 they insist on compensation and management of rainwater at source.
505 Their positions (and aspirations) were even bolder during the focus
506 group (in which only one elected official was involved) than during the
507 interviews. There was a kind of reinforcement effect of the
508 statements, encouraged by a low presence of the political actors. The
509 claim of this manager of the *Lez/Mosson* watershed attests to their
510 ambitions and efforts.

511 *“In the framework of urban renewal, in fact everything that has been*
512 *excessively concreted, everywhere where there are a lot of pavements,*
513 *car parks, we try to optimise these sectors by removing the concrete*
514 *and creating green areas... It's written into the Regional water*
515 *management plan...”.*

516 In fact, recently, localized actions have also been carried out, thanks
517 to fundings from the RMC WA to depave schoolyards in Montpellier
518 3M. The first tests were launched in 2021. The main argument in
519 favour of this works was however more to fight against urban heat
520 islands and to restore biodiversity. It is worth noting that French public
521 schoolyards are mostly covered with concrete or bitumen, and
522 sometimes partially covered with a rubber coating to cushion the falls
523 of the youngest. A few trees provide some shade, even if their roots
524 are embedded in artificial materials (Pandelle, Le Roux 2021). Children
525 have very limited contact with the natural elements. In Montpellier
526 3M , where temperatures already exceed 28°C at the end of June and
527 beginning of July, these artificial zones contribute to increasing
528 temperatures. Since municipalities manage school buildings and there
529 are financial incentives for re-greening, choices are done to start
530 where it easier, in small spaces and with spatially limited issues.
531 Depaving in other parts of the city, however, raises other questions
532 and problems.

533 d- Other obstacles and levers.

534 The main obstacle identified by all those interviewed, and in particular
535 by the elected officials, is the financial and salary cost for installing and
536 maintaining permeable infrastructure – once we had specifically
537 mentioned them (during the interviews and the focus group).

538 *“The cost of management is terrifying, especially if it’s small green*
539 *spaces scattered all over the place. By the time the guys get there,*
540 *come back, it’s a horror.”*, said an elected official.

541 The costs are obviously difficult for municipalities to accept. Yet the
542 interviewed also pointed out the strong constraints that the
543 regulations impose on real estate developers who must apply the
544 regulations - which means devoting part of the land they acquire,
545 whether in urban renewal or new neighbourhoods, to the
546 construction of storm drains and ditches or more. For them, this is a
547 loss of earnings that can give rise to resistance as mentioned by
548 another elected official:

549 *"It is excessively heavy and expensive because land in Montpellier 3M*
550 *is not cheap! When you carry out a real estate operation and there is*
551 *already a significant cost of land, of destruction, of restructuring, plus*
552 *a lot of standards that are put in place to have a rather pretty city with*
553 *quality architecture etc., and you tell the guy, whether he is a private*
554 *individual or a developer, 'ah I forgot to tell you that on 10 to 15 % of*
555 *impervious soils today, you will have to go back to perviousness'... In*
556 *some places, it means attacking several layers of bitumen, perhaps*
557 *digging out pollution!"*

558 The longer-term benefits of alternative or greener urban development
559 methods and techniques (for the management of rainwater) are rarely
560 highlighted - even if they are emphasised by the state services.
561 Prescriptions in the domain are seen above all as an additional cost
562 and a constraint that is poorly understood. In some cases, in heritage
563 areas or areas where pollution is suspected, additional expenditure
564 can be required, either to protect historical monuments and buildings
565 or to rehabilitate land.

566

567 Moreover, while coating materials such as concrete and bitumen (or
568 paving stones) can be installed by the road services for many years,
569 and are easily cleaned by the cleaning services, alternatives require
570 more attention. Pervious bitumen is costly and last less time. It tends
571 to clog and requires maintenance (Denis, Pontille 2015). It makes
572 underground networks repairing more expensive. For other pervious
573 infrastructures it is not only necessary to mobilise the 'parks and
574 gardens' department, but also to try to bring together services that
575 often work in silos to collaborate because their professional cultures
576 are not the same (Meilvang 2021). The road technicians, like those of
577 the sanitation services, have always worked to evacuate rainwater as
578 quickly as possible. They do not see water as a resource, but as a
579 problem. Their way of doing things is the opposite of the way of the
580 'parks and gardens' department - which agents usually operate in
581 dedicated spaces that they control and not in the permeable city, i.e.
582 a hybrid of streets and greenery. As underlined by a State official, it is
583 therefore necessary to develop new transversal approaches.

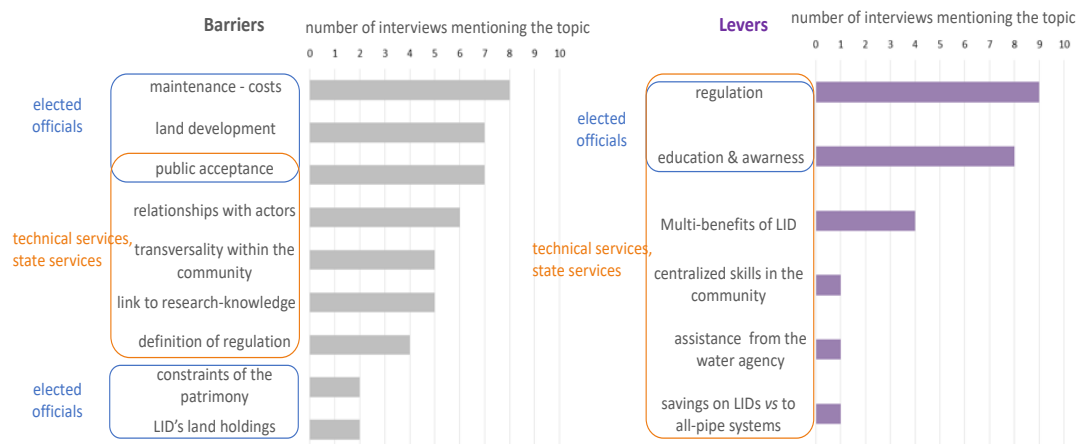
584 *"Sanitation is simple. There is a service that takes care of everything.*
585 *As soon as you do with alternative techniques, it can be different with*
586 *sanitation, road, and green space services. It is more difficult. The*
587 *transversality within the municipalities is not completely acquired and*
588 *it is necessary to work on it".*

589 There is a problem of both financial resources and human resources.
590 The regular maintenance of a green and blue infrastructures requires

591 more staff, and staff trained in other methods and techniques that are
 592 much less focused on one sector than previously. It is a question of
 593 dealing with vegetation that must be pruned, with animal or plant
 594 species that may proliferate, but also with changing states of matter,
 595 for example, when it rains, mud may form. The predictability of
 596 surfaces made homogeneous by a uniform impervious coating
 597 disappears in favour of diversity and change. Municipalities not always
 598 put the necessary funding into this because, as we have said, it is not
 599 their priority and other risks may appear to be of greater interest to
 600 them (flood control and the securing of public spaces). Yet large cities
 601 like Montpellier 3M are already spending a lot of money on upgrading
 602 their obsolete storm drainage networks - an effort that is largely
 603 invisible and therefore difficult to promote.

604

605



606

607 Table 2: Barriers and levers for the development of alternative
 608 techniques in interviews (Source: Rio 2020)

609

610 Among the other brakes and limits we have listed in Table 2, there are
611 also the anticipated negative reactions of inhabitants. As mentioned,
612 the French are used to cities where nature is entirely domesticated
613 and even confined to strictly limited spaces in French style public parks
614 and gardens as well as private gardens. Any irruption of alien animal
615 or bloom of plants is viewed with suspicion. For example, the elected
616 officials we met worried about unhappy constituents. They foresee
617 that depaving more would induce the increase of complaints as they
618 experienced with the ban of pesticides in public spaces. Alternative
619 and greener approaches could then be seen as manifestations of
620 neglect and dereliction.

621 *"Vegetation today in an urban environment is complicated to manage,*
622 *it creates enormous tensions with our populations because as we no*
623 *longer use phytosanitary products, and we don't have the means to*
624 *pay guys to pull it out by hand, and we still haven't found the biological*
625 *means to maintain it, people see trees growing everywhere, they say*
626 *that we don't maintain the roads, that we don't maintain the*
627 *pavements, 'what the hell is this mess'!" (Elected official).*

628 For this reason, all the interviewees indicated that educating the
629 population is the solution to avoid such negative feedbacks. For a
630 representative of the Montpellier 3M : *"we need to change*
631 *mentalities"* to prepare the reception of new and lighter ecological
632 infrastructures. To this, it would be necessary to add experiences of
633 consultation in order not to remake the city for (or against) its

634 inhabitants, but with them. This would avoid frontal opposition. It
635 could also lead to the emergence of preferences which should be
636 considered. This is the conviction of an elected official of Montpellier
637 3M , also mayor of a small town to the North of the city, who has
638 played an important role in the implementation of democratic local
639 water policies.

640 *"Urban renewal requires much more consultation than urban*
641 *development... It is normal if your living environment is modified*
642 *under your windows.*

643 However, the neighbourhood associations we met still regretted being
644 so little consulted. Most of the stakeholders had only partial
645 information on the hydrological, chemical, social and political issues
646 raised by rain and runoff. It was therefore difficult for them to envisage
647 the greening of their city, with its democratic implications, especially
648 as relations with local scholars were rather weak – compared to places
649 like the Lyon Metropolis where there are intermediary actors who act
650 as a link between scientists, decision-makers, and citizens.

651

652 **3. Discussion**

653 Our sociological survey was conducted in 2019, at the same time as
654 we performed hydrological and chemical measurements in the
655 *Verdanson* catchment area in the heart of Montpellier 3M. The results
656 allowed us to develop several scenarios of population and urban
657 growth to model the evolution of the quality of the stream in the

658 future - according to public policies (Rio et al. 2021). They also helped
659 us to target and prioritise feasible depaving actions, which would have
660 the most beneficial consequences in terms of decreasing the quantity
661 of runoff and improving the quality of surface waters.

662 This action research aimed at solving a water-in-the city problem.
663 However, we quickly realised that the technical knowledge we had
664 produced would not be enough. The implementation of alternative or
665 greener runoff management techniques does not only depend on the
666 concrete enumeration of its advantages by a group of convinced
667 scientists. It also requires political and social support to be
668 implemented and work. For this reason, we took the time to analyse
669 the interviews we had conducted for drawing the necessary lessons.

670 In particular, we noticed that the issue of river and stream quality,
671 whatever the kind of contaminants found in urban settings, was not
672 identified as a public problem in the sense that the sociologist Joseph
673 Gusfield have given to this term (1984; Gilbert, Henry 2012): a
674 phenomenon or issue that has been problematised in such a way as to
675 be identified as a concern and, as such, taken on by institutions. This
676 approach has the advantage of not suggesting that the issues are self-
677 evident. On the contrary, it shows that they are socially constructed -
678 remaining ignored until social actors not only take the trouble to
679 investigate them, but also manage to have them publicly accepted as
680 relevant and urgent to address. In our case, substantial efforts would
681 be needed to raise awareness of the issues at stake: i.e. to make
682 explicit the links between the water quality of runoff and the

683 degradation of the aquatic lagoon and marine environments located
684 downstream of Montpellier 3M. Indeed, the risk is great that these
685 coastal aquatic ecosystems do not meet the objectives set by the WFD,
686 in time. Long-term awareness-raising work, initially aimed at the
687 technical services of municipalities throughout the catchment area,
688 would be necessary so that concerns about flooding are correlated
689 with water quality problems in the city and its downstream coastal
690 waters. Other issues such as urban heat islands in paved areas or
691 biodiversity erosion could be connected to this. However, this
692 awareness raising could not be only informative. It should aim at
693 transforming professional and citizen cultures about nature in the city,
694 as, alternative rain management interventions refer to other
695 conceptions of urbanity. They also imply a hybridisation of knowledge
696 and know-how that is not only valid in Montpellier 3M but potentially
697 in other urban areas of Southern Europe. Our regional prism is all the
698 more relevant as it refers to comparable climatic conditions (extreme
699 weather events) and urban cultures.

700 In those areas where elected officials are slow to be convinced by
701 greener techniques for managing runoff, for all the reasons we have
702 seen, it would undoubtedly be possible to rely on the specialised
703 associations which have expertise in this field, and which appeared to
704 us as pioneers of the idea of a permeable city recently. It is a question
705 of setting up an integrated and concerted management of rainwater
706 to limit the flow of water, and by the way, to fight against flooding
707 together with dissemination of contaminants, but also to retain the
708 water necessary for the greening of the city. In Montpellier 3M , the

709 associations have expressed many expectations in this area. They also
710 have a lot of proposals to make. We are not at all in the situation of
711 those of Northern European and American cities where citizens'
712 groups take the initiative to make the soil permeable again, by
713 breaking up the concrete and bitumen of their streets. We remain
714 within the French framework where these actions are the prerogative
715 of the municipalities (or other competent local institutions). However,
716 there is a good chance that these associations could relay the needs
717 of the inhabitants and users or, conversely, serve as third-party
718 mediators to explain certain decisions in favour of perviousness, – like
719 it happened in 2021 in Milan or Parma, Italy, very recently (Ceci et al.
720 2023).

721 Efforts in terms of consultation would not be useless. During a recent
722 field trip, we were able to interview an amateur on his way to his
723 vegetable garden located in shared communal land near a new
724 neighbourhood called *Malbosc*. We asked him about the dog run,
725 which is a retention basin. He surprised us by answering that the site
726 had been badly designed as it flooded every time it rained. This
727 experience was repeated during a walk with a group of students from
728 Montpellier University in a "rain garden" on the campus. Without
729 explanation, the students saw nothing of the device designed to drain,
730 thanks to a set of subtle slopes, the rainwater towards green spaces at
731 the foot of the buildings.

732 These examples show us that alternative green methods and
733 techniques are not immediately visible to those who have not learned

734 to see them. As a result, the devices concerned are unable to
735 demonstrate their ecological and social benefits. The only functions
736 that are apparent are often the possible disamenities associated with
737 the removal of impermeable coatings and the installation of pockets
738 of potentially proliferating nature in the city, as we have already
739 mentioned. Given the demographic and urban growth in Montpellier
740 3M, it is likely that storm basins, ditches, and urban parks (mandatory
741 compensatory measures) - or even the depaving of a few car parks and
742 schoolyards (main real greening interventions at this date) - will not be
743 enough to truly compensate for the future artificialisation of further
744 natural spaces. In this respect, this metropolis represents an extreme
745 case, with environmental, social and economic tensions, from which
746 to consider the development of depaving in other urban areas of the
747 Mediterranean.

748 Other more far-reaching and long-time actions must nevertheless be
749 considered to maintain the habitability of the areas concerned, both
750 in terms of their capacity to absorb increasingly rare and intense
751 rainfall, to limit the concentration of contaminants in runoff and to
752 avoid heat urban islands - all of which requires a balanced renaturation
753 of the city. The expected changes demand, however, what the
754 philosopher Alexandre Monnin calls: an art of destoration (2021), i.e.
755 methods and tools for thinking about the dismantling of modern
756 infrastructures, the drawbacks of which we can now see - even though
757 they appeared to be the markers of technical and social progress. How
758 can we get rid of the concrete and bitumen that cover our cities to the
759 point of depriving us of all contact with the natural elements of the

760 soil? How can we learn to do without their practicality? Without
761 doubt, the ecological transition cannot be achieved by simple decree
762 or the prescriptions of new technical standards. It has to be learnt and
763 experienced collectively.

764

765 **Conclusion**

766 In 2019, the representatives of Montpellier 3M whom we interviewed
767 spoke of a future greening plan for the city as the incentives of the
768 RMC WA became more and more pressing. While ambitious plans
769 have been announced since our survey, with the future depaving of
770 larger portions of public spaces, clearly this plan does not yet exist. We
771 have not been able to obtain a copy of it to check. Depaving is still
772 included in the SCOT but without any more constraints than before.
773 We note, however, that the Metropolis has hired, at the beginning of
774 the winter of 2022, a project manager whose main missions will be to
775 promote depaving actions. During the last few years, things have
776 accelerated, particularly under the influence of the summer intense
777 heat waves and drought. The need to cope with this dramatic situation
778 could open new possibilities. To rethink the place of water in the city
779 and to green its management, new interdisciplinary research in urban
780 hydrosociology will certainly be necessary - both to change
781 organisational, professional and citizen cultures, but also to set to
782 music the indispensable collaborations (Aimar 2023). Montpellier 3M,
783 given its climatic specificities, will not become a "sponge city". Neither
784 will be Marseille (France) nor Naples (Italy). However, they could be

785 become metropolises like Barcelona or Valencia, in Spain (Suleiman
 786 et al. 2020), where the pace of water has been significantly slowed
 787 down (Gies 2022), thanks to greener participative approaches of
 788 urbanism so living conditions are significantly improved with regard
 789 to future threats.

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