Evacuation simulation using MATSim

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City of Padang, Western Sumatra, Indonesia

Padang

- about 800,000 inhabitants
- located at the West Coast of Sumatra (0°57′0″S 100°21′11″E)
- area 694.96 km^2
- elevation about 3 m
- density 1090/km^2

Source: DLR Oberpfaffenhofen, 2007 / Spatial Planning Western Sumatra Prov., 2006

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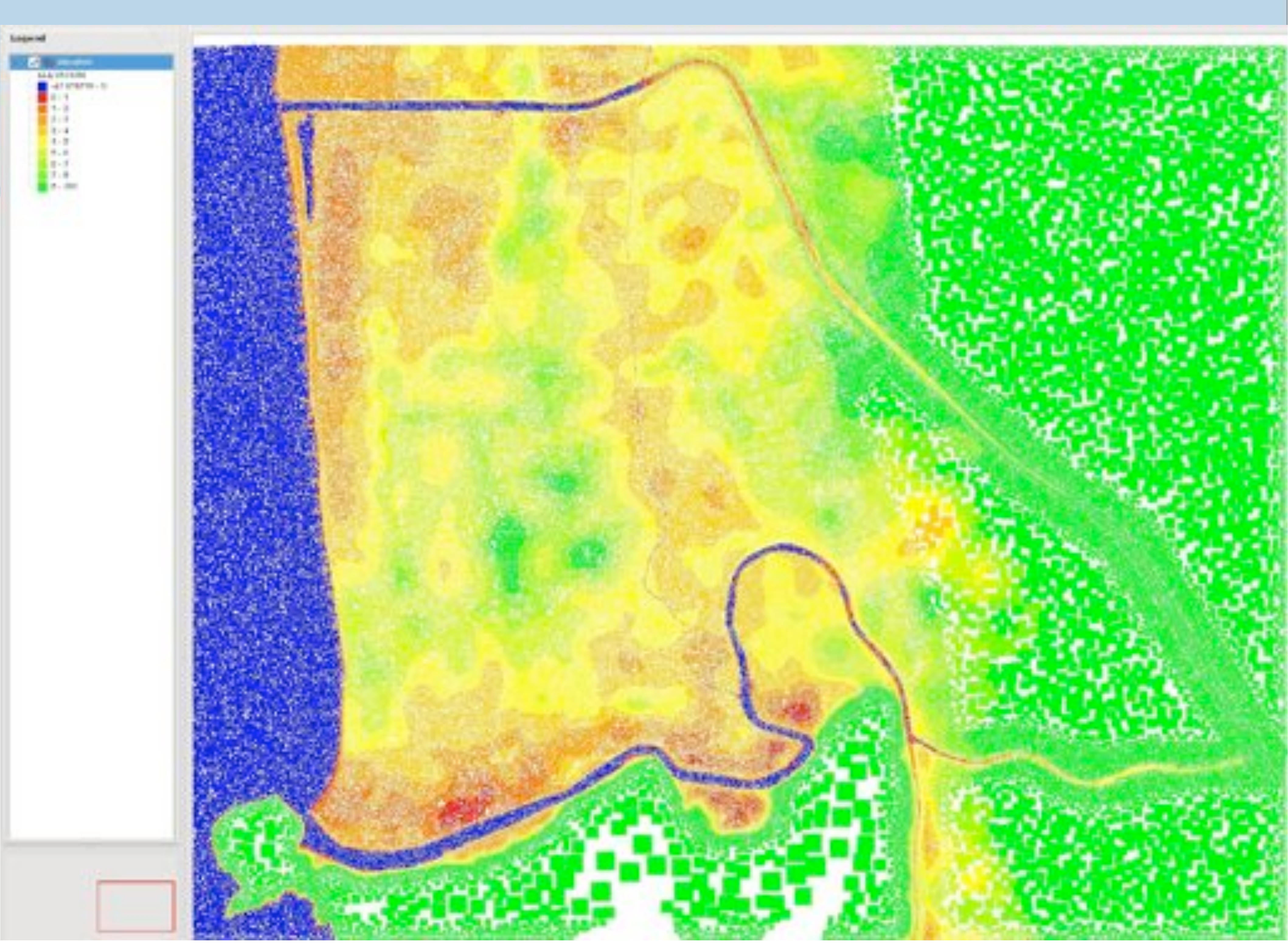

Simulation of the evacuation process

- estimation of evacuation time
- detection of bottlenecks
- detection of highly endangered areas

===> Derive evacuation recommendation

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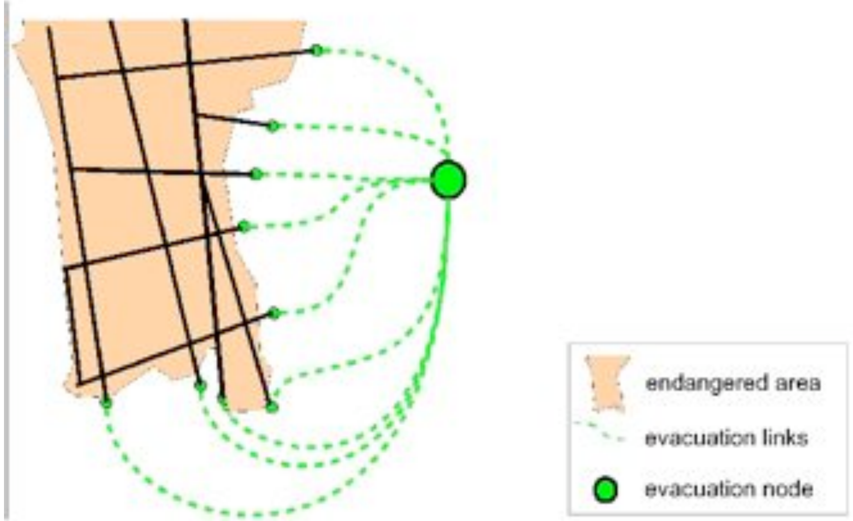
Evacuation simulation – scenario

Network

- extracted from satellite imagery
- 6289 nodes
- 16978 links

Population

- from census data
- assuming all people at home
- “3:00am” - scenario



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Scoring

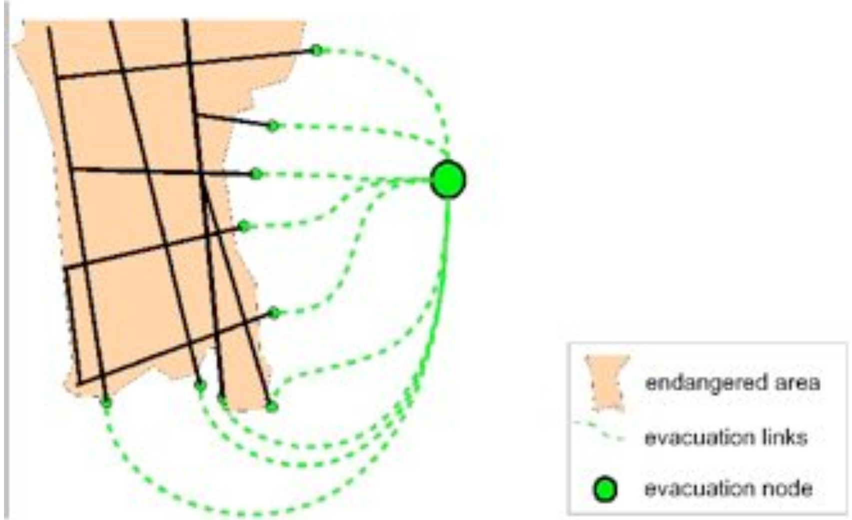
- score is just the negative of the evacuation time

Routing

- multi-destination problem reduced to a single-destination problem

Flooding information

- provided by Franzius-Institute at University Hannover
  ===> time variant network



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Time variant networks

Change events definition

```
<networkChangeEvent startTime="08:00:00">
      <link refId="1"/>
      <link refId="2"/>
      <flowCapacity type="scaleFactor" value="0.5"/>
      <freespeed type="absolute" value="13.88"/>
      <lanes type="absolute" value="1.0"/>
</networkChangeEvent>

<networkChangeEvent startTime="14:00:00">
      <link refId="2"/>
      <link refId="1"/>
      <flowCapacity type="absolute" value="1.5"/>
      <freespeed type="scaleFactor" value="36.11"/>
      <lanes type="scaleFactor" value="3.0"/>
</networkChangeEvent>
```

Config file

```
<module name="network">
      <param name="inputNetworkFile" value="&INPUTBASE;/padang_net_v20080618.xml" />
      <param name="localInputDTD" value="&LOCALDTDBASE;/network_v1.dtd" />
      <param name="outputVersion" value="v1" />
      <param name="outputNetworkDTD" value="&LOCALDTDBASE;/network_v1.dtd" />
      <param name="timeVariantNetwork" value="true" />
      <param name="inputChangeEventsFile" value="&INPUTBASE;/padang_change_evac_v20080618_of10min.xml" />
</module>
```

Implementation transparent for router and mobsim

```
public class TimeVariantLinkImpl extends LinkImpl {

/**
 *
 * @param time - the time in seconds.
 * @return the freespeed at time <tt>time</tt>.
 */
@Override
public double getFreespeed(double time) {
if (freespeedValues == null)
initFreespeedValueMap();
return freespeedValues.floorEntry(time).getValue();
}

/**
 * @param time - the time in seconds.
 * @return the freespeed travel time at time <tt>time</tt>.
 */
public double getFreespeedTravelTime(double time) {
return getLength()/getFreespeed(time);
}

/**
 * @param time - the time in seconds.
 * @return the flow capacity at time <tt>time</tt>.
 */
public double getFlowCapacity(double time) {
if (this.flowCapacityValues == null)
initFlowCapacityValueMap();

return this.flowCapacityValues.floorEntry(time).getValue();
}
```

Time variant network for evacuation simulation

As soon as a link is flooded it's free speed will be set to zero

```
<networkChangeEvent startTime="04:57:00">
  <link refId="104405"/>
  <link refId="5019"/>
  <link refId="105019"/>
  <link refId="4405"/>
  <freespeed type="absolute" value="0.0"/>
</networkChangeEvent>
```

Simulation runs

Evacuation at 3 am

Trying to optimize against a fixed advance warning time does not lead to a feasible solution

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Evacuation at 3 am

run313

advance warning time

it0-it200 8.5 min

it201 28.5 min

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Evacuation at 3 am

run310 vs. run313

Simulating with a shorter advance warning time until Nash equilibrium is reach and then run one further iteration with the actual advance warning time helps, but ...

... may be a behavior that minimizes the risk of being catched by the wave would be better.

==> adding risk depending costs to the links

GIS analysis

How can we derive evacuation recommendation from these results?

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Installing signs on every crossing?

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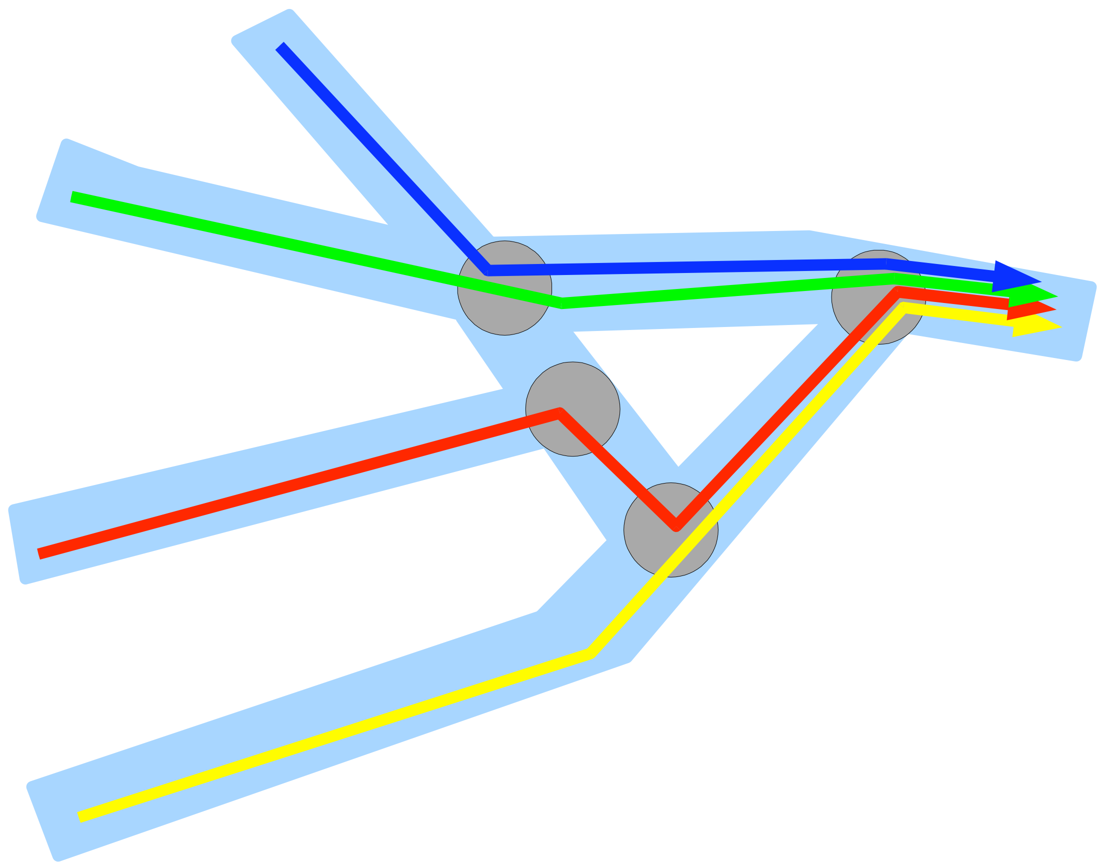
Discussion

How can we derive evacuation recommendation from these results?

Installing signs on every crossing?

Would only work for confluent flows.

Confluent flow: A solution is called confluent if and only if all the flow at any node leaves along a single fixed link all the time.



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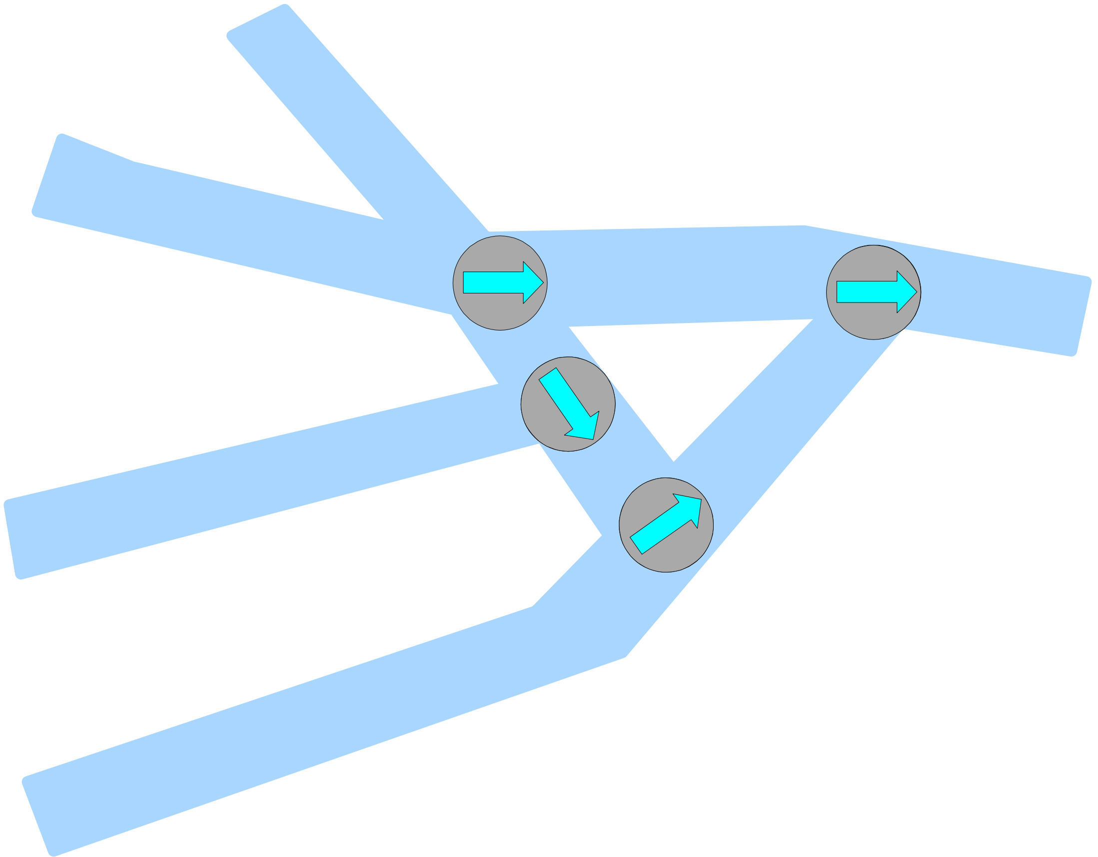

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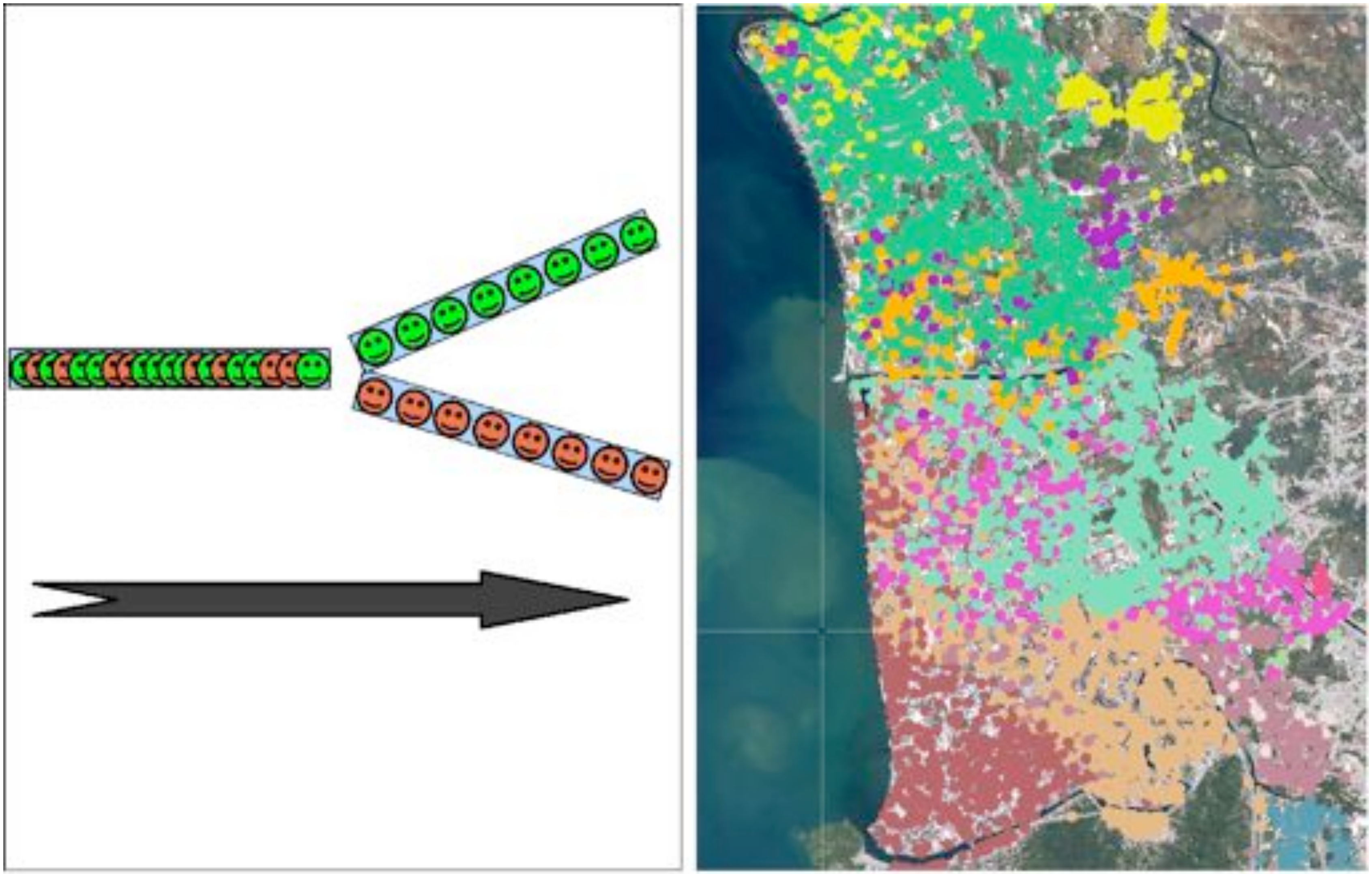
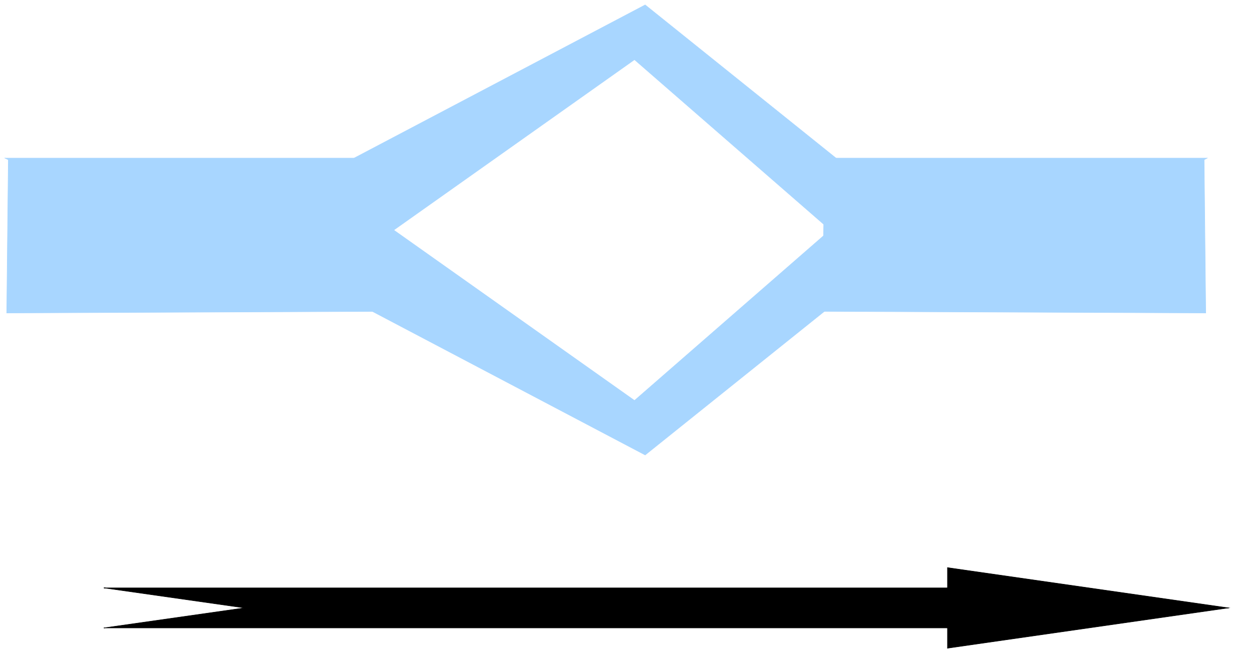
Discussion – confluent flow



a) b)

Discussion – confluent flow



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Conclusion

DONE

- initial scenario works
- estimate of the evacuation process

TODO

- risk aversion (potential field approach?)
- derive recommendation (confluent flow problem)

Thank you for your attention!