Modeling and Designing the Future of Irrigation

Designing a Low- Pressure, Off- Grid Drip Irrigation System which is economically viable for small- scale farmers

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Motivation

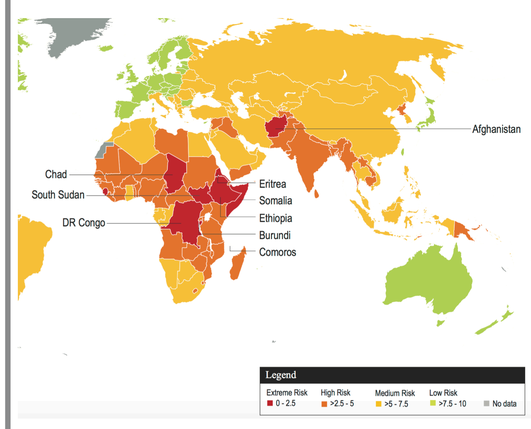
The world is facing a **water and food crisis** as a result of climate change, population growth (9 billion by 2050) and lack of water efficiency [1,2].

Drip irrigation is a potential solution

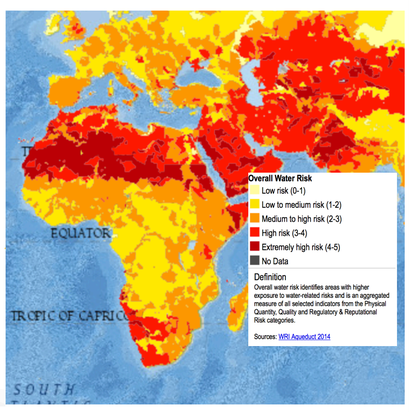
- Reduces **water consumption** by **30-70%**
- Increases **crop yields** by **20-90%**
- Can grow water sensitive cash crops
- Reduce fertilizer usage by up to 40%

The Challenge: High costs prevents large-scale dissemination

- **~$1500/acre** for drip irrigation system and additional **$1500** for solar power system.
- **80%** of cost is **power and pumping systems.**



Food Security Risk Index [3]

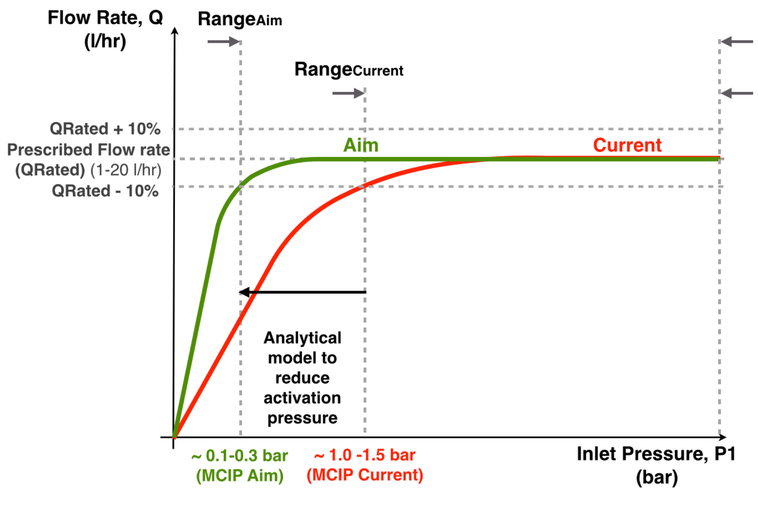


Water Risk Index [4]

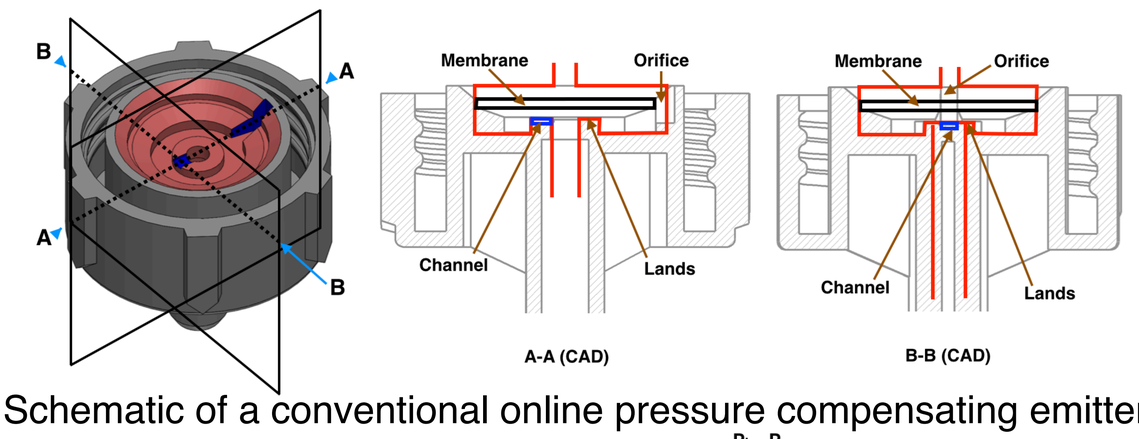
Proposed Solution

A technological breakthrough is needed

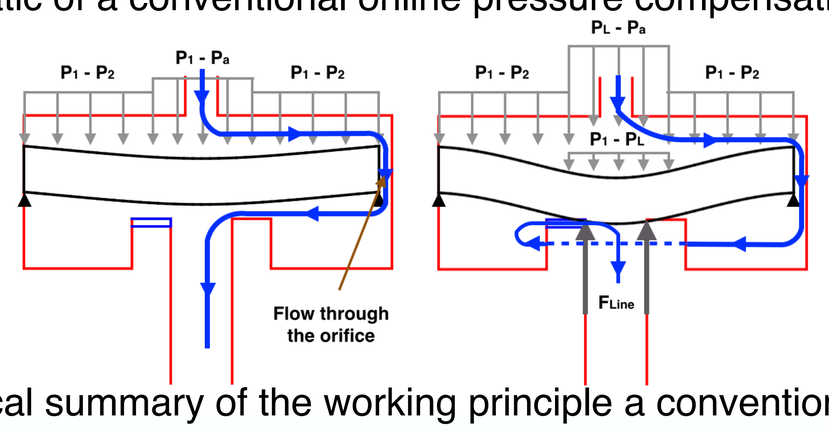
- Pumping power = **Pressure** x flow rate
- Current pressure demand is **~ 2 bar**
- Major Pressure losses (**~50%)** is the Activation pressure of Pressure Compensating (PC) emitter, **~1 bar**
- **10 times** reduction in activation pressure can reduce cost by **50%**



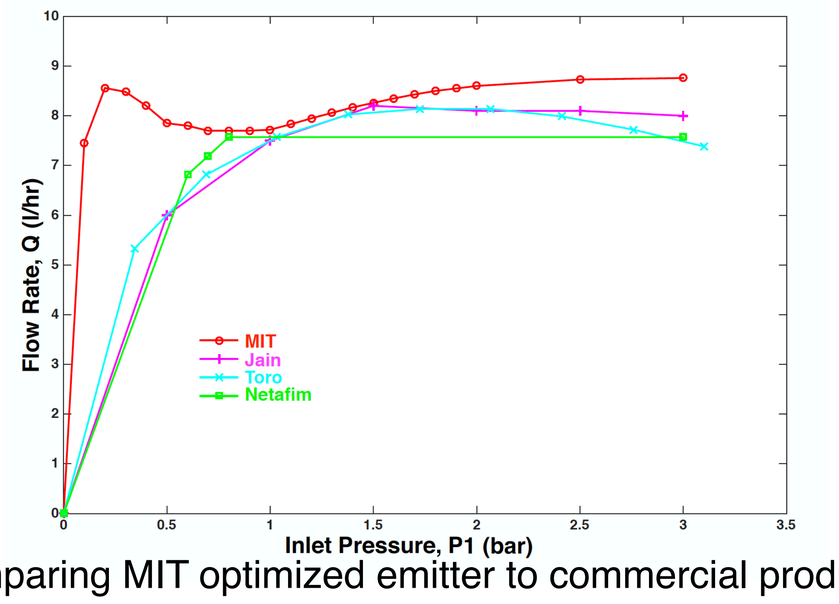
Prototype [5]



Schematic of a conventional online pressure compensating emitter



Graphical summary of the working principle a conventional emitter



Comparing MIT optimized emitter to commercial products

Conclusions

- At MIT, by analytically modeling an online emitter and optimizing it's geometric parameter, a **reduction of activation pressure** from **1 bar to 0.15 bar** was achieved. It is estimated that the **cost** of the system can be **reduced by 50%** by using this emitter.

Next Steps

- The next step is to optimize the whole drip irrigation system, this includes reduction in pressure losses within pipes, filters and fertigation system.

References

[1] Taylor et al. (IDETC 2015)- A Mathematical Model for Pressure Compensating Emitters.
[2] Shamshery et al. (PLOS ONE- in review)- Modeling the future of irrigation: a parametric description of pressure compensating drip irrigation emitter performance.
[3] Maplecroft (2013)- Food Security Risk Index
[4] WRI (2014)- Water Risk Indiex
[5] Shamshery et al. (US Patent- 62/258067)- Pressure Compensating Emitter Having Very Low Activation Pressure and Large Operating Range

Acknowledgments

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