

2016 ICM
Problem E
Are we heading towards a thirsty planet?

Will the world run out of clean water? According to the United Nations, 1.6 billion people (one quarter of the world's population) experience water scarcity. Water use has been growing at twice the rate of population over the last century. Humans require water resources for industrial, agricultural, and residential purposes. There are two primary causes for water scarcity: physical scarcity and economic scarcity. Physical scarcity is where there is inadequate water in a region to meet demand. Economic scarcity is where water exists but poor management and lack of infrastructure limits the availability of clean water. Many scientists see this water scarcity problem becoming exacerbated with climate change and population increase. The fact that water use is increasing at twice the rate of population suggests that there is another cause of scarcity – is it increasing rates of personal consumption, or increasing rates of industrial consumption, or increasing pollution which depletes the supply of fresh water, or what? **

Is it possible to provide clean fresh water to all? The supply of water must take into account the physical availability of water (e.g., natural water source, technological advances such as desalination plants or rainwater harvesting techniques). Understanding water availability is an inherently interdisciplinary problem. One must not only understand the environmental constraints on water supply, but also how social factors influence availability and distribution of clean water. For example, lack of adequate sanitation can cause a decrease in water quality. Human population increase also places increased burden on the water supply within a region. When analyzing issues of water scarcity, the following types of questions must be considered. How have humans historically exacerbated or alleviated water scarcity? What are the geological, topographical, and ecological reasons for water scarcity, and how can we accurately predict future water availability? What is the potential for new or alternate sources of water (for example, desalinization plants, water harvesting techniques or undiscovered aquifers)? What are the demographic and health related problems tied to water scarcity?

Problem Statement

The International Clean water Movement (ICM) wants your team to help them solve the world's water problems. Can you help improve access to clean, fresh water?

Task 1: Develop a model that provides a measure of the ability of a region to provide clean water to meet the needs of its population. You may need to consider the dynamic nature of the factors that affect both supply and demand in your modeling process.

Task 2: Using the UN water scarcity map (<http://www.unep.org/dewa/vitalwater/jpg/0222-waterstress-overuse-EN.jpg>) pick one country or region where water is either heavily or moderately overloaded. Explain why and how water is scarce in that region. Make sure to explain both the social and environmental drivers by addressing physical and/or economic scarcity.

Task 3: In your chosen region from Task 2, use your model from Task 1 to show what the water situation will be in 15 years. How does this situation impact the lives of citizens of this region? Be sure to incorporate the environmental drivers' effects on the model components.

Task 4: For your chosen region, design an intervention plan taking all the drivers of water scarcity into account. Any intervention plan will inevitably impact the surrounding areas, as well

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问题 E 我们是否正走向一个
缺水的星球？

世界会面临清洁水资源短缺吗？据联合国统计，全球有 16 亿人（占世界人口的四分之一）面临水资源短缺。过去一个世纪以来，用水量的增长速度是人口增长速度的两倍。人类需要水资源用于工业、农业和生活用途。水资源短缺主要有两个原因：自然资源短缺和经济资源短缺。自然资源短缺是指一个地区的水资源不足以满足需求。经济资源短缺是指水资源虽然存在，但由于管理不善和基础设施不足，导致清洁水的供应受到限制。许多科学家认为，气候变化和人口增长将加剧水资源短缺问题。用水量增长速度是人口增长速度的两倍这一事实表明，水资源短缺还有其他原因——是个人用水量的增长，还是工业用水量的增长，抑或是污染加剧导致淡水资源枯竭，又或是其他什么原因？

能否为所有人提供清洁的淡水？供水必须考虑水的物理可利用性（例如，天然水源、海水淡化厂或雨水收集技术等技术进步）。了解水的可利用性本身就是一个跨学科问题。我们不仅要了解供水的环境限制，还要了解社会因素如何影响清洁水的可利用性和分配。例如，缺乏足够的卫生设施会导致水质下降。人口增长也会增加区域供水的压力。在分析水资源短缺问题时，必须考虑以下几类问题：历史上人类是如何加剧或缓解水资源短缺的？造成水资源短缺的地质、地形和生态原因是什公么？我们如何才能准确预测未来的水资源可利用性？新的或替代水源的潜力如何（例如，海水淡化厂、雨水收集技术或尚未发现的含水层）？与水资源短缺相关的人口和健康问题有哪些？

问题陈述

国际清洁水运动（ICM）希望您的团队能够帮助他们解决世界水资源问题。您能否为改善人们获得清洁淡水的途径贡献一份力量？

任务一：建立一个模型，用于衡量一个地区向其居民提供清洁水以满足其需求的能力。在建模过程中，您可能需要考虑影响供需双方的动态因素。

任务二：利用联合国水资源短缺地图

（<http://www.unep.org/dewa/vitalwater/jpg/0222waterstress-overuse-EN.jpg>），选择一个水资源严重或中度超负荷的国家或地区。解释该地区水资源短缺的原因和方式。务必从社会和环境两个方面解释其驱动因素，并阐述自然资源短缺和/或经济资源短缺的问题。

任务 3：在你从任务 2 中选择的区域，利用你在任务 1 中建立的模型，展示 15 年后该区域的水资源状况。这种情况将如何影响该区域居民的生活？

务必把环境因素对模型组成部分的影响纳入考虑。

任务 4：针对你选择的区域，设计一个干预计划，并考虑所有导致水资源短缺的因素。任何干预计划都不可避免地会对周边地区产生影响。

as the entire water ecosystem. Discuss this impact and the overall strengths and weaknesses of the plan in this larger context. How does your plan mitigate water scarcity?

Task 5: Use the intervention you designed in Task 4 and your model to project water availability into the future. Can your chosen region become less susceptible to water scarcity? Will water become a critical issue in the future? If so, when will this scarcity occur?

Task 6: Write a 20-page report (the one-page summary sheet does not count in the 20 pages) that explains your model, water scarcity in your region with no intervention, your intervention, and the effect of your intervention on your region's and the surrounding area's water availability. Be sure to detail the strengths and weaknesses of your model. The ICM will use your report to help with its mission to produce plans to provide access to clean water for all citizens of the world. Good luck in your modeling work!

Possible Resources

An Overview of the State of the World's Fresh and Marine Waters. 2nd Edition, 2008. (<http://www.unep.org/dewa/vitalwater/index.html>).

The World's Water: Information on the World's Freshwater Resources. (<http://worldwater.org>).

AQUASTAT. Food and Agriculture Organization of the United Nations. FAO Water Resources. (http://www.fao.org/nr/water/aquastat/water_res/index.stm).

The State of the World's Land and Water Resources for food and agriculture. 2011. (<http://www.fao.org/docrep/017/i1688e/i1688e00.htm>).

GrowingBlue: Water. Economics. Life. (<http://growingblue.com>).

World Resources Institute. www.wri.org.

**Note that the 2013 Mathematical Competition in Modeling (Problem B) and the 2009 High School Modeling Competition in Modeling (Problem A) were related to modeling different aspects of water scarcity.

Your ICM submission should consist of a 1 page Summary Sheet and your solution cannot exceed 20 pages for a maximum of 21 pages. Note: The appendix and references do not count toward the 20 page limit.

作为一个整体的水生态系统。请在此大背景下讨论其影响以及该计划的总体优势和劣势。您的计划如何缓解水资源短缺问题？

任务 5：利用你在任务 4 中设计的干预措施和你的模型，预测未来的水资源可用性。你选择的区域能否降低缺水风险？水资源未来是否会成为一个关键问题？如果是，这种短缺何时会发生？

任务 6：撰写一份 20 页的报告（一页的摘要不计入这 20 页），解释你的模型、你所在地区在无干预情况下的水资源短缺情况、你的干预措施，以及

您的干预措施对您所在地区及周边地区水资源供应的影响。

请务必详细说明您模型的优势和劣势。ICM 将利用您的报告来协助其制定计划，为全世界所有公民提供清洁用水。祝您建模工作顺利！

可能的资源

世界淡水和海洋水体状况概述。第二版，2008 年。

(<http://www.unep.org/dewa/vitalwater/index.html>)。

世界水资源：世界淡水资源信息。

(<http://worldwater.org>)。

联合国粮食及农业组织水资源统计数据库 (AQUASTAT)。联合国粮食及农业组织。粮农组织水资源。http://www.fao.org/nr/water/aquastat/water_res/index.stm)。

2011 年世界粮食和农业用地及水资源状况。

(<http://www.fao.org/docrep/017/i1688e/i1688e00.htm>)。

GrowingBlue：水、经济、生命。[\(http://growingblue.com\)](http://growingblue.com)

世界资源研究所。www.wri.org。

**请注意，2013 年数学建模竞赛（问题 B）和 2009 年高中建模竞赛（问题 A）与水资源短缺的不同方面建模有关。

您的 ICM 提交内容应包含一份 1 页的摘要表，且您的解决方案不得超过 20 页，最多不超过 21 页。注意：附录和参考文献不计入 20 页的限制。