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ANALYSIS OF RELEVANT RAINWATER HARVESTING LEGISLATION FOR LEBANON'S URBAN AREAS

COMPARISON OF RWH GUIDELINES, BYELAWS AND INCENTIVES IN AN INTERNATIONAL CONTEXT AND POSSIBLE RECOMMENDATIONS FOR LEBANON'S LEGAL FRAMEWORK

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COMMITTEE DECISION

This Thesis/Dissertation (Analysis of Relevant Rainwater Harvesting Legislation for Lebanon's Urban Areas – Comparison of RWH Guidelines, Byelaws and Incentives in an International Context and Possible Recommendations for Lebanon's Legal Framework) was Successfully Defended and Approved on

Examination Committee
Signature

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List of Acronyms

RWH – Rainwater Harvesting
MAR – Managed Aquifer Recharge
MoEW – Ministry of Energy and Water
TCEQ – Texas Commission on Environmental Quality
CIV – Commercial Incentive Program
TRHEC – Texas Rainwater Harvesting Evaluation Committee
TSBPE – Texas State Board of Plumbing Examiners
MOU – Memorandum of Understanding
INBC – Indian National Building Code
HUDA – Haryana Urban Development Authority
CGWA – Central Ground Water Authority
UDD – Urban Development Department
SLAC – State Level Advisory Committee
TPD – Town Planning Department
CBO – Community Based Organization
BWSSB – Bangalore Water Supply and Sewerage Board
PWD – Public Works Department
WB – World Bank
CWSSP – Comunity Water Supply and Sanitation Project
LRWHF – Lanka Rain Water Harvesting Forum
NRPS – National Rainwater Policy and Strategies
BOI – Board of Investments
UDA – Urban Development Authority
RDA – Road Development Authority
NWSDB – National Water Supply and Drainage Board
ARID – Australian Rainwater Industry Development Group
SNUWES – Sustainable National Urban Water and Energy Savings Program
WTCS – Water Trading Certificate Scheme
NSW – New South Wales
WWRDC – Woolworths Wyong Regional Distribution Center
NSWCCF – New South Wales Climate Change Fund
RHAA Rainwater Harvesting Association of Australia

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Abstract

Rainwater harvesting is an important technique that grants an important water income to countries facing water scarcity and other water-over-exploitation related problems. Lebanon has untapped potential in harvesting rainwater, but what are the needed tools to implement rainwater-harvesting systems by achieving consensus in the community? In this thesis the legislative tools such as laws, by-laws, policies, amendments, tax and cost rebates, loans, subsidies, etc., of four countries that are vanguards in this field (Australia, India, Sri Lanka and the USA) are shown and analyzed. Some aspects were found to be in common among these countries, others were country-specific. This heterogeneity, considering the defined dimension of the thesis focusing on specific cases, allows a broader overview of these tools. Output of the thesis is a matrix giving a one-glance overview of these legal tools in all mentioned countries. If action is to be undertaken, an expert panel, including all identified key stakeholders, should be created to cooperate in the creation of a rainwater harvesting feasibility and implementation strategy.

Introduction

Rainwater harvesting (RWH) is an ancient technique that has been gradually replaced by modern era technologies and other water sources, and is coming back with particular momentum. Many civilizations lived and survived thanks to RWH in cities situated away from water bodies. Nowadays the need for RWH is even more pronounced, in varying aspects, than in the past. Almost all countries and cities in the world rely on groundwater for their water supply, which has been a reliable source of clean water. This is also the case in Lebanon, although the quality of groundwater cannot be qualified as good because of various factors such as the absence of wastewater treatment plants and the geology of the soil, which allows a high flow speed of the water underground.

At present the hydrological situation in Lebanon is alarming. Due to geopolitical developments, affecting the whole region for decades and exacerbated in particular with the Syrian crisis, the country hosts millions of refugees. While official sources estimate 1.5-2 million refugees, unofficial sources indicate they number around 3 million. Although Lebanon is considered a water rich country among the MENA region, a population rise of at least 1/3 means putting water resources under unsustainable stress.

Population growth is not the only cause calling for action in the water sector though. The lack of urban planning in the current uncontrolled urbanization process puts the very existence of aquifers at stake. There are areas of the capital where water quality is very bad, e.g. Hamra and Ras Beirut, because saltwater has infiltrated the aquifers (due to over-extraction). Furthermore, many new buildings are being constructed in these areas.

In this context the feasibility of RWH systems is a valid solution to be explored, partially tackle the status quo, especially since Lebanon is considered a water rich country within the MENA region (mean annual precipitation ca. 890mm/y). Urban areas do not only need water for consumption, but they are also faced with a series of issues arising from water shortage/contamination, such as urban flooding, depletion of aquifers, etc. RWH is a suitable method to deal with all these issues. Many countries and cities around the world use RWH to secure water for their citizens, implement rainwater collection systems to protect cities from the rainy season floods, and to raise the groundwater table through artificial infiltration, etc.

There are different RWH techniques, depending on the kind of collection that is desired and the geographical location. All of the techniques are reliable, but how is implementation achieved from an empirical point of view? Telling someone to invest in something, even if it is beneficial for all parties involved, will result in a suspicious reaction. This is undoubtedly human nature. So what are the means to convince, persuade, and let people embrace the change that is urgently needed? In this thesis possible means will be explored, taking note of a wide array of solutions used in different countries. These countries are the avant-garde of RWH, not only at the technological level,but also at a legal level. Policies, legislations, incentives, subsidies, loans, tax, and cost rebates are the means to convince people and foster change. It is undeniable that when you address people regarding a strong belief or even an existential need, special consideration must be paid to the person's wallet. A government must be ready to invest money to facilitate implementation, this will encourage citizens to take the all important first step Moving towards change is easier if something material is offered and; change through coercion, i.e. legistlation, has often proved to be counterproductive. These may seem like logical thoughts, but they are surprisingly often forgotten or underestimated. When proposed change affects the vast majority of citizens, a well-thought plan is of the utmost importance.

The results outlined in this GIZ-supported thesis concern Managed Aquifer Recharge (MAR) to tackle sea water intrusion in the aquifer of Hazmieh, Beirut, where RWH, along with other techniques such as wastewater treatment, was identified as a possible mean to provide water for infiltration or to directly/indirectly release the stress put on the aquifer.

Positive outcomes of RWH systems implementation will be shown alongside mismanagement cases, since they are complementary and of equal importance.

The objective of the thesisis to focus on RWH legislations, incentives, etc., to see what kind of commitment needs to be shown by the government and what means should be used in order to facilitate the integration of RWH in a given society. It is hoped that the information collected here will start a meaningful dialogue about the usefulness of RWH among the Lebanese water sector stakeholders.

Australia

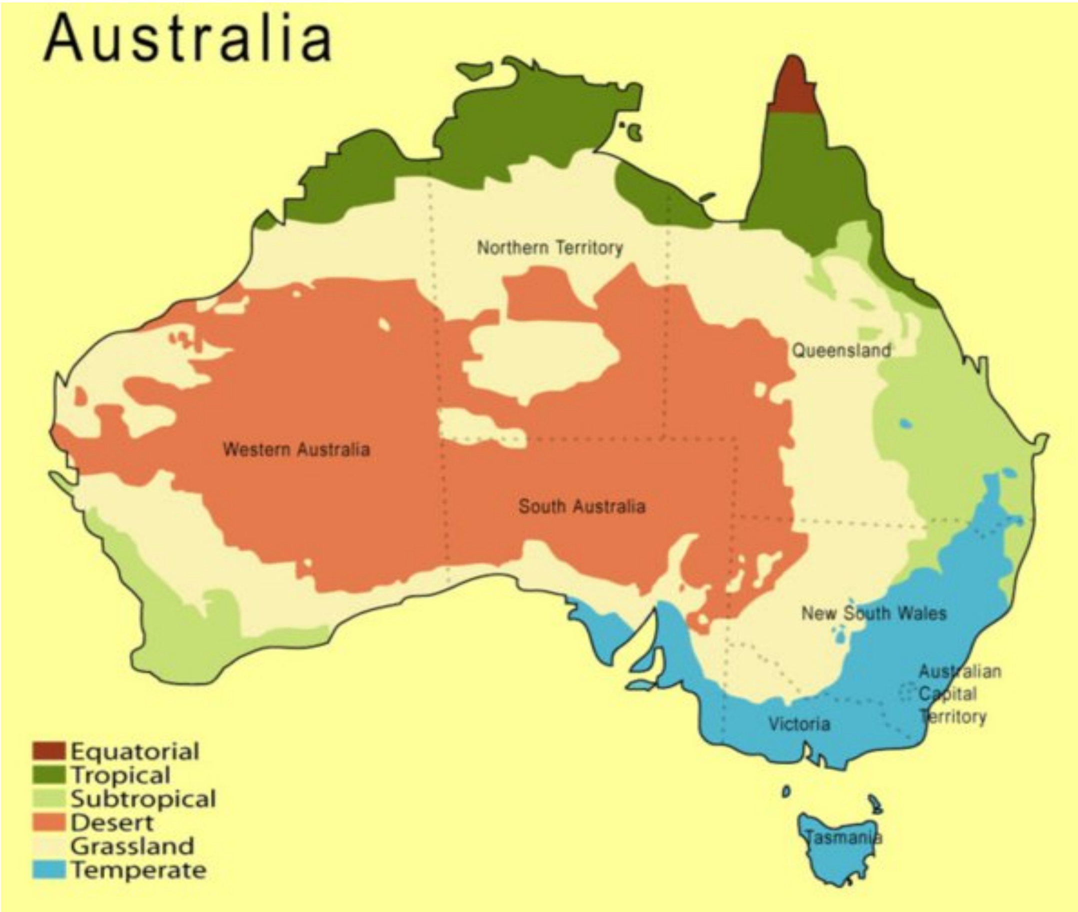

Figure 1, Australian climate regions, www.nature-education.org, 2014

Introduction

Australia is one of the driest populated continents on earth with an extremely unsteady rainfall. Water supply became a major issue in the country due to the urbanization rate and the persistent droughts in the last decade. Among the alternative water sources (RWH, grey water reuse, and wastewater recycling) being contemplated as possible counteraction, RWH received the highest consideration because it is fresh water and can be easily harvested and used for non-potable purposes. Nevertheless, many Australians are diffident towards adopting RWH systems. As shown by the Australian Bureau of Statistics (ABS), approximately 47% of the answers of the survey stated that the principal cause for not implementing a RWH system was the perceived high cost (Rahman, et al., 2011).

Nevertheless most Australian cities have a solid background in RWH, since it was, and in various cases also nowadays, the only water supply. The socalled Millennium Drought, lasting more than ten years in Australia (1997-2009) saw a reduction of rainfall and runoff amounts that had devastating effects. This very phenomenon put RWH again into the foreground. A good example showing this phenomenon is the city of Adelaide where the percentage of households using RWH went from 38% to 45% during the Millennium Drought (California Delegation to Australia, 2014).

Still, most homeowners do not promptly see the gain of RWH systems in the long term; this is probably related to a lack of understanding of the life cycle costs of the system. The feasibility of RWH systems varies from country to country and also from region to region of a country. While studies conducted in Barcelona showed that the payback period for the investment would vary between 33 and 61 years, depending on tank size and type of building, in Melbourne the payback period, considering the range of different variables would be between 15 to 21 years. Also other studies like the one conducted by Tam et al. (2009) (as cited in Rahman et al., 2011), which investigated the economic feasibility of RWH systems in residential areas in Australia, demostrates how such structures could guarentee financial benefits for Brisbane, Sydney, and the Gold Coast thanks to a higher rainfall as compared to that of Melbourne (Rahman, et al., 2011).

Implementation Strategies and Status Quo

The Australian Rainwater Industry Development Group [1] (ARID) issued a discussion paper entitled "Implementation of a Sustainable National Urban Water and Energy Savings Program" (SNUWES), where important reflections about steps to be accomplished for a broad and balanced implementation of RWH systems are made. The strategy was conceived to exploit the full potential of environmental and economic benefits of

[1] ARID: now Rainwater Harvesting Association of Australia (RHAA) is a non-profit organization which assists manufacturers and industrial segments active in RWH in promoting the benefits of rainwater and the reuse of water. The main objective is to achieve water sustainability at community level.

water and energy savings. Its potential was identified in the following key points:

- Reduce government expenses by providing a more economically feasible option for governments than short-term rebates
- Move towards a long-term approach
- Promote a method suitable for all building types and for RWH by using a range of potential water sources
- Choose a coherent approach on a national scale that allows flexibility for future as well as present technology and climate conditions
- Pledge not to raise present energy consumption and greenhouse gas emissions
- Government support for the development of Australia's technology sector and export market
- Raise consumer's awareness regarding energy and water conservation via the use of alternative sources such as rainwater, greywater, and recycled water
- Change the present and future behavioural approach
- Decrease drinking water consumption
- Spread the uptake and use of water and energy saving devices among the citizens by advocating nationally-consistent requirements for installation, harvesting, and usage

- Maintain the feasibility of the alternative water industry utilizing future scenario planning/forecast about growth and needs in order to raise investments in the sector
- Ensure that Australia continues being forerunner in these emerging technologies

After identifying the potential of such a change, ARID made the following core recommendations:

- Make determined decentralized water and energy savings systems compulsory to be implemented in all new resdential and comemrcial buildings.
- Make it compulsory to adopt decentralized water and energy saving systems when selling an existing building or make the installation of approved water and energy saving devices such as dual flush toilets, water saving showerheads, etc., obligatory in order to achieve a minimum of 40% water and energy saving over current practices.

Although ARID is first and foremost a rainwater industry group, its strategy opted for an approach that would include different water and energy saving schemes, since RWH alone is not considered to be the solution to Australia's problems. The other side of the coin was the fear of the effect that the implememted strategy would have on the affordability of houses. But it is clear that reaching a 40% energy and water savings and long-term financial and environmental benefits, as shown by different studies, has certain upfront costs.

Many states already made water and energy savings obligatory, due in part to consumer support. Any expenses incured in implementing systems for water and energy savings that were recommended by the strategy would be recovered when the property is sold and supported by government and energy/water market incentives. In case the property should come to a mortgage sale, it would be sold with the obligation to achieve the required environmental savings. By adopting such a strategy, ARID showed how 90% of all Australian households could achieve a 40% (or more) water and energy savings within the next ten years. The program suggests the inclusion of the above-mentioned requirements in the Real Estate Act and in the Building Code of Australia, thus eliminating the need of monitoring or enforcement by a national authority. Similar cases show that inclusion in acts/codes, such as with mandatory installation of smoke detectors, can achieve the desired result. At least this was the comparison chosen by ARID (ARID & MPMSAA, 2008). Although the idea can be considered valid, the basis for this comparison is weak because amending a law in order to include smoke detectors in a building can be seen as an individual step. While a strategy that not only includes RWH, but also other water saving as well as energy saving measures, and including this strategy in a policy or law, is a process that involves different stakeholders, is more of a revultion, is time consuming, and must be well-thought-out since, as we could and will see, it is a change both sensible and fundamental.

In this sense, ARID defines its approach as evolutionary considering that many aspects of the strategy were adapted from existing regulations, guidelines, and discussion papers. This ‘evolutionary approach’ was selected in order to create a Best Practices balanced proposition that should be included in a National Sustainable Water and Energy Savings Program. According to the statements, such national strategy would provide the majority of buildings in Australia with safe water while at the same time having low greenhouse gas emissions for essential services (toilet, laundry and outdoor uses) and hence use less water and energy (ARID & MPMSAA, 2008).

Economic and environmental benefits were also proven after research conducted by Marsden Jacobs Associates[2], showed that harvested rainwater used in loco has greenhouse gas and

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[2] Marsden Jacob Associates is a consultancy agency providing economic, strategic, and public policy advice to the Australian government and the private sector. Their independent advice in the water sector has promoted policy development and efficient investment for 20 years. Their main focus is the investigation of the cost effectiveness of water tanks for RWH in urban Australia.

climate benefit over mains drinking water and other innovative water supply solutions. The outcome of the reasearch also showed how water tanks have a five times higher efficiency than the proposed Traveston Dam, when measured per megalitre of water produced.

Through the proposed approach, the rainwater industry reliance on government rebates will be reduced, giving this sector the opportunity to regain confidence and invest in a long-term sustainable market, which for Australia is also an important mean to keep its position as world leader in water saving technologies and inevitably have a positive effect on exports. The potential of these initiatives is big and the two main gains were found to be:

- 30 to 40% reduction of potable water consumption
- save up to $60m^3/y$ per household[3]

The rainwater industry in Australia has gone from one extreme to the other, and many of these experiences can be categorized as 'Lessons Learned'. In the years 2006 and 2007 the RWH

[3] If applied to 7.4 million buildings over ten years, the annual water savings would be about 444 MLN of m^3.

industry was in good standing, being pushed by high consumer demand, and in turn sustained by government rebate schemes. The scenario caused a high unexpected demand which was answered by the industry with a production increase. That in turn required heavy investments. Only one year later, in 2008, the situation changed radically. Decreasing consumer demand and rising confusion were created by changing rebate conditions that invevitably had a major impact on the economics of this industrial segment, resulting in a decrease between 40 and 60% (ARID & MPMSAA, 2008). To have a succinct comparison between the two years, the following table is striking. Seeing such an empass blocking the way to a successful implementation of a strategy is of interest, especially to get an insight into which solutions are possible and how to apply them.

Rainwater Industry in 2006/07	**Rainwater Industry in 2008**
4.500+ people directly employed in the industry	3.000+ people directly employed in the industry
13.000+ people indirectly employed	10.000+ people indirectly employed
Industry output $1.30 BLN	Industry output: $800 MLN
> 10.000 l manufactured water tanks: 350.000+	> 10.000 l manufactured water tanks: 200.000+
< 10.000 l manufactured water tanks: 80.000+	< 10.000 l manufactured water tanks: 50.000+
Produced water pumps > 800 watts: 190.000	Produced water pumps > 800 watts: 150.000
Produced water pumps < 800 watts: 30.000	Produced water pumps < 800 watts: 20.000
Estimated saved drinking water: 23.220 BLN liters	Estimated saved drinking water: 12.000 BLN liters

If we further depict the current situation, we see that only 21% (1.5 out of 7.4 million households) in Australia possess a RW tank. On average 150,000 new housing units are erected each year, while about 800,000 homes are sold per annum. According to these figures we see what potential is left untaped.

To improve water tank usage in cities and suburbs would mean a release of pressure from mains water supply, or rather as the use of a complementary source while concurrently protecting local waterways from runoff damages and lowering the need for costly stormwater infrastructure.

Estimations show how the rebates offered by the government for water saving technologies cost the state $800 million for 2006/07. The products for which rebates were offered included a wide set ranging from RWH tanks, to shower heads, greywater systems, dual flush toilets, garden watering devices, and high pressure cleaners. What directly leaps out is that such a strategy is economically unsustainable for the government and confusing for any consumer (although profitable). Besides being a non-beneficial strategy for the government and the consumers, a further spanner in the way of successful implementation is that the real cost of water has been undervalued for far too long in Australia, leading to an intricate situation where the government sets a strategy, businesses working in the water sector have to commit to it, trying to generate an own income while giving economic advantages to the customers and investments are made without uniting short, mid, and long-term scenario planning (ARID & MPMSAA, 2008). Lacking these elements, a strategy thought to deal with a radical change will experience set backs in an advanced phase, which will have highly negative effects since the stakeholders will find themselves involved in dealing with two issues at the same time: finding a way out of the wrong strategy while keeping the momentum credible in front of the eyes of civil society.

ARID supports the idea of state and federal government rebates in sustaining the installation of RWH systems until fully operational and sees the most viable alternative as the creation of a Water Trading Certificate Scheme (WTCS). This WTCS would work based on the succesful parallel of the Renewable Energy Certificate Scheme, which supported customers with the installation costs of renewable energy products. To explain it briefly, the community invested in an energy saving technology (solar hot water, photovoltaic) and each customer would be awarded a number of certificates corresponding to the amount of energy saved. These certificates are then sold to the energy market to meet any deficiency that may occur in meeting their green electricity targets. The value of certificates is subjected to fluctuations according to the needs of the energy market (ARID & MPMSAA, 2008).

Case Studies

Queensland

This brief case study shows how important cooperation and proper communication are among stakeholders in order to avoid later recoil. The average household rebates for water saving products ranges between 20 and 60% of the products cost. In 2006/07 in the south east of Queensland, house owners could apply for both state and local government rebates for the same product. This means that they could (in the best case) recuperate the costs of the material investment and the installation expenses, theoretically causing zero costs to the householder. The effect of this uncoordinated action was a steep rise in the rainwater tanks demand and the industry investing heavily in order to satisfy the demand in a short period of time. When short-term rebates were removed or changed, the industry felt the recoil in terms of economic losses (ARID & MPMSAA, 2008).

New South Wales (NSW)

- Household level: In the State, thanks to the Dual Flush Toilets Rebate Program that began in the second half of January 2010, over 15.800 households received the rebates ($200 per toilet).

This program cost the government \$3.1 million and has the potential to sace ca. 395,000 m^3 of water per annum.

- Business level: The Woolworths Wyong Regional Distribution Center (WWRDC) (Woolworths Limited is the biggest supermarket chain in Australia), located on the NSW Central Coast, implemented a RWH scheme thanks to the funding of the Central Coast Water Savings Fund, which made \$150,000 available for its implementation. Since WWRDC has a high water demand to be able to operate its on site cooling towers, four 260m^3 water tanks have been installed to catch rainwater from the large roof area of the center. Already in the first year the water costs were reduced by \$20,000 and ca. 20.8 million liters of potable water are being catched and used on site every year for the cooling towers, toilet flushing, irrigation, and in emergency cases for the local Rural Fire Service (NSWCCF Annual Report, 2011).
- Sydney: Here is an interesting case study explaining the economic twist in which RWH is involved. It involved a simulation of the city of Sydney with a 75 m^3 rainwater tank The performance of RWH structures concerning water savings was found to be directly proportional to the size of the roof and to the water needed. Furthermore, in most of the scenarios that were simulated, RWH did not turn out to be a sustainable option from an economic point of view, considering the current water prices in Australia (highly subsidized) and the high interest regime (more than 7%). In a few simulated cases, where interest

rates were smaller and water prices higher, RWH proved to be a feasible option. This is because capital costs are the biggest component in the overall costs of a RWH system, directly followed by maintenance costs (Rahman, et al. 2011). As suggested by ARID, the results showed that the government should consider an increase of the subisidies for RWH systems both to counterbalance the high financial investment of home owners and to stimulate the implementation of RWH systems. Also, the environmental benefits such as water conservation, on-site retention of pollutants as well as the other benefits such as the enhancement of the urban water supply system resilience can be expected. RWH systems implementation could also have a push-back effect on the realization of major water supply projects like dams and desalination plants, undeniably a positive outcome (Rahman, et al., 2011).

Incentives

The Australian authorities offer financial incentives in the frame of state and territory programs to persuade home owners to implement RWH systems among other water and energy saving technologies. While the SNUWES depicted and commented above presented energy and water saving measures as a 'single body', below is a list of incentives pertaining exclusively to RWH systems.

Victoria

The state of Victoria has the Living Victoria Water Rebate Program which awards citizens for their commitment towards water saving measures by providing rebates. The rebates are offered for a selected range of water efficient products to be used around homes, gardens, and small businesses. The current incentives program is valid for products bought between the 01.07.2012 and the 30.06.2015 and offers:

- Rainwater tank rebates of $850 for 2.000 – 3.999 liters connected to toilet and/or laundry.
- Rainwater tank rebates of $1.300 to $1.500 for 4.000 or greater connected to toilet or laundry.
- Tank to toilet/laundry connection $500.
- Tank rebates were extended to existing buildings which obtained the permit btween 01.07.2005 and the 01.05.2011.
- Washing machine rebates for 5-star water and 4-star energy models.
- Small businesses can apply for rebates of up to $2.000 (per business) for the purchase and installation of selected products, devices, and services (Victorian Government Department of Sustainability and Environment, 2012).

New South Wales

The New South Wales Climate Change Fund (NSWCCF) supplies $123 million to sustain houselholds, businesses, community groups, and the government to save 19.8 billion liters of water and $49 million in water bills per year. To accomplish this, 607 projects, 141,104 residential rebates, and 18,855 public housing retrofits were planned. Water rebates for residential properties were eligible until 30.06.2011 for:

- RWH tank rebates of $150 for 2000 to 3999 liter tanks plus $500 if connected to toilet/washing machine by plumber.
- $400 rebates for a 4000 to 6999 liters tank plus $500 if connected to toilet/washing machine by plumber.
- $500 rebates for tanks with a capacity higher than 7000 liters plus $500 if connected to toilet/washing machine by plumber.
- Schools installing rainwater tanks can apply for a rebate of up to $2500.
- Rebates amounting to $150 for the purchase of a 5-star water efficiency washing machine were offered for a maximum of one washing machine per household and only for personal use.

Limitations regarding the above described rebates, concerning water tanks, state that:

- Tanks must have a minimum capacity of 2000 liters capacity and have been installed between the 01.07.2007 and the 30.06.2011.
- If a household is not connected to the mains supply system, it can apply for the tank-purchase rebate only.
- If a tank was bought to fulfil the Building Suitability Index for new homes, major renovations or a pool installation, it is not eligible for a rebate (NSW Climate Change Fund, 2011).

Western Australia

Western Australia implemented the H2O Assist program to support residential and business customers to realize the shift towards water use reduction by implementing water saving technologies offered at a fixed price and guaranteeing support with the installation. The requirements to be able to apply were mainly concerning the building's connection to a reticulated water supply served by the Water Corporation and to agree to its terms and conditions (of the Water Corporation). The incentives offered proposed different items to reduce prices:

- Three types of toilets costing between $385 and $600
- Two types of rainwater tanks, both of a 2000 liters capacity, costing $1150 or $1750 (Water Corporation, 2014).

Conclusion

As could be seen, Australia is a forerunner in RWH practices at the urban level .A mix of rebates, legislative tools, and programs were studied and implemented in order to achieve a spatially inclusive outcome as well as water and energy efficient measures enforcement. Collecting informations regarding strategies, rebates, etc., is not easy and the accessible information that could be gathered were not always structured in the same way. However, the furnished overview attempted to give a snapshot of the complexity of the holistic approach pursued by the Australian government in drafting a strategy whose appeareance and structure reminds the one of the Water Food & Energy Nexus. Uniting energy and water savings potential in a single strategy seems to be a very logical step since they are related on an empirical level where economic savings and environmental thinking present mutual benefit. It is unavoidable for the success of such strategies to initially look at the direct benefits arising from the implementation, then to explore what the indirect benefits are and subsequentcause-effect relationship. Indirect benefits are greatly undervalued, e.g. “We implement RWH systems at urban level, which effects are a rise in the water table and avoiding the construction of urban flood-prevention structures”. They hence often present more benefits than meet the eye when, and one should consider these links carefuly. This also applies in the opposite scenario where fundamental links are missed, leading to similar set backs outlined aboce in Australia (promising scenario in 2006/07 to regression in 2008).

India

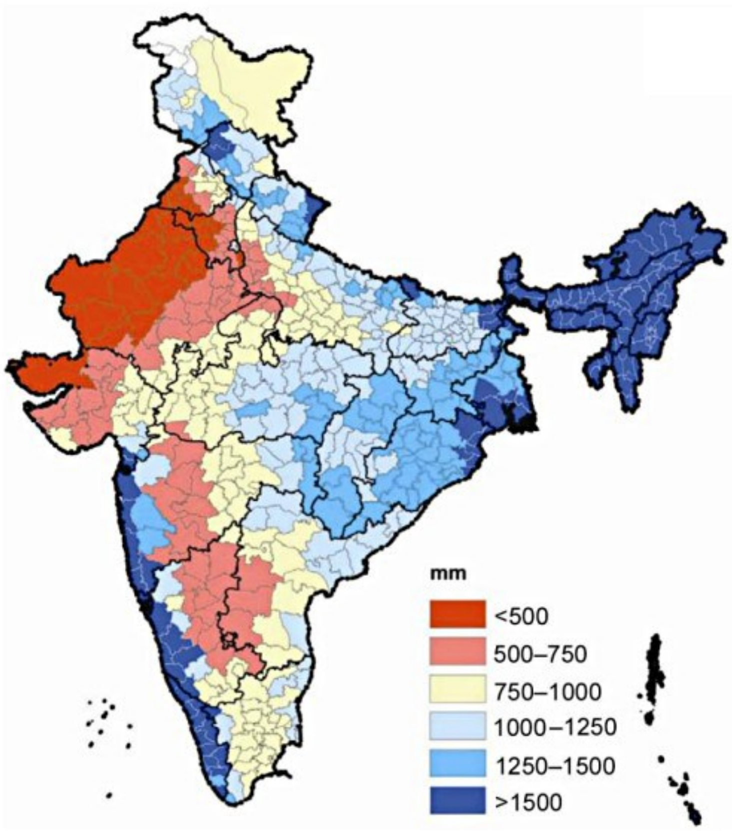

Figure 2, rainwater fall in mm/y in India, www.makanaka.com, 2014

Introduction

India is probably the country with the most ancient rainwater harvesting experience worldwide. It already started implementing RWH structures around 2,000bc. Before looking at single case studies and legislations developed by specific cities/states, it is interesting to see how the Indian National Building Code (INBC), published in 2005, includes RWH regulations in various sections.

The 1157 page document is divided into several categories, including administrative aspects, building materials, structural design, etc.

Administrative aspects concerning RWH:

- The development/building authorization, if given by the competent authority, shall incorporate a landscape development plan and include RWH proposals in the layout and building plans.
- The service plans must include all details regarding the building, included RWH systems if there are any.

Requirements for parts of buildings:

- Roofs of buildings shall be designed as to guarantee an effective drain of water from the rooftop through rainwater pipes of suitable size, ensuring that water drain does not affect in any way walls, roofs, or foundations of the building and thereby causing dampness.

Drainage and sanitation (planning and design considerations):

- In general this section states how RWH is the ideal source to supplement the continuous growing gap between available water resources and the demand for those resources. It also states that the variation of rainfall patterns from region to region must be considered, and each state has to develop its own policies for RWH.
- Artificial groundwater recharge – considering the increasing amount of impermeable surfaces in urban areas, a large quantity of water that would normally infiltrate the ground runs off, and if it does not create problems downstream (e.g. floods), it gets lost. If we consider this lost water as a potential resource the main objectives of artifical groundwater recharge are:

  - Enhance the sustainable yield in areas where there is over-development and depletion of the aquifer
  - Conserve and store excess surface water in aquifers
  - Improve the quality of groundwater
  - Maintain the natural balance of the groundwater

- Harvesting RW in urban areas usually does not allow storeage of large quantities of harvested rainwater, and is hence best suited for aquifer/groundwater recharge (INBC, 2005).

In Lebanon urban runoff causes anannual loss of 0.4 BCM to the sea. Part of this water would otherwise naturally infiltrate the soil and work as an aquifer recharge mean.

In general the above considerations also apply to Lebanon, although the INBC does not include incentives, which will be subject matter of the research hereinafter. It is interesting to see how India managed to include RWH in the national building code. This fact apparently seems distant from practical inclusion, but is indeed strictly related to it; raising awareness and including RWH in a national code would denote that RWH is integral part of present and future strategies to solve a matter of great urgency.

Chennai

In October 2002 the Tamil Nadu government enacted a law which was follwed by an ordinance in June 2003 making the implementation of RWH systems obligatory in all buildings, wether being built or already existing, by October 11, 2003. This law establishes that "wastewater from the bath and wash basin shall be treated by organic or mechanical recycling and taken to a sump for onward pumping to an exclusive overhead tank for use in toilet flushing. Any excess shall be connected to the rainwater harvesting structures for groundwater recharge". In order to set an example, the government implemented RWH systems in every one of its departments, while the Chennai Corporation[4] implimented RWH systems in public spaces such as roads, schools, parks, and their own quarters.

What makes the Chennai experience of interest is the fact that civil society and government were working together to implement RWH in the city. NGO's participated in the project in order to to raise awareness and garner support among citizens. Even ten years later, the government (with the help of local NGO's) continues monitoring and carrying out audits via third parties. This shows how implementation is never the last step since there are always margins for improvement, and continuous monitoring is especially needed for strategies/techniques that are not yet established.

The benefits derived from the Chennai experience were both direct and indirect. One of the biggest direct benefits was flood mitigation. Suitable structures were implemented as e.g. storm water or recharge pits placed in public spaces in order to keep the roads from being flooded. In the area of Chennai the quantity and qualilty of available groundwater were both shown to be improved were RWH was implemented, as was shown in

[4] Chennai Corporation: The civic body governing the city of Chennai.

2006 when the Rain Center[5] conduced a survey proving how the water table had risen by six meters. Considering the fact that different designs need to be created according to specific urban contexts, especially if RWH is to be combined with aquifer recharge, the Chennai experience shows how these changes are feasible from a technical and economic point of view and potentially effective for other similar urban locations (Gopalakrishnan et al., 2012).

Being on the one side a success story of a holistic approach involving different actors, the Chennai experience also shows how in reality, according to Raghavan[6], only 50% of the implemented RWH systems were successful in their purpose because they were applied in an ineffective way. Nevertheless Raghavan himself sees the Chennai experience as a paradigm showing what political will can achieve in a realtively short time. On one hand the partial success of the law was caused more due to the fact that people had to follow this law, and not

[5] Rain Center: is an association that was created in Chennai and is active in awareness raising campaigns, implementation excercises, as well as surveys and studies. The association participates in initiatives such as „Catch Every Drop".

[6] Raghavan: recognized as a profound example of civil society comitment towards change. This exeptional man quit his job as a physics professor to show the Chennai citizens the importance of RWH for the city. He recognized the potential and the need and through his will he managed to achieve great result, of which the first was that Tamil Nadu made RWH obligatory for all properties in Chennai

due to a generated social awareness leading people's actions. On the other hand many cases displayed improper implementation of the RWH systems (Raghavan, 2013). Lesson learned is hence that commitment on both social and political level is needed and that awareness campaigns are important before such laws are enacted, especially if they have a short-term deadline.

The Sundram Fasteners Ltd (SFL) Case Study in Padi (Chennai)

Not having an in-house source of water, the factory was entirely dependent on purchased water initially, which would be bought either from the Chennai Metro Water or from tankers supplying water extracted from distant wells. Consequently SFL spent around $58,000 per year for its water supplies. In order to cut on the water expenditures, SFL contracted the KRG Rainwater Foundation[7] to implement an on site RWH structure in several phases.

[7] KRG Rainwater Foundation: the foundation is composed of professionals,including engineers, geologists, hydro-geologists, soil conservationists, and remote-sensing experts that give advice regarding implementation of RWH systems to India's areas which are most in need.

- In the first phase the entire SFL roof area of 18.000 m^2 was connected to a storage area via pipes and rainwater collection chambers. Thanks to the accomplishment of the first phase, SFL was able to collect over 1300 m^3 of water (equal to a five days water consumption by the factory), being able to save approximately $840 with the rain that would fall in eight days. The expenses for Phase I were around $8,100.
- In the second phase the rejuvenation of an open well was targeted. Thanks to the water made available through Phase I, the quality of the well water was greatly enhanced and the well, became more and more productive, allowing about 150 m^3 to 200 m^3 to be pumped out of the well daily.

Delhi

Back in December 2002 the government of Delhi, aware of the necessity to implement RWH systems, created a financial assistance scheme for RWH in South and South West Delhi. This subsidy scheme was to be handled bythe registered Resident Welfare Associations and the Cooperative Housing Societies, and the funds were to be handed out by the Delhi Jal

Board[8]. In August 2004 this scheme was extended to the entire Delhi area, only a few parts in northern Delhi where excluded. The scheme included financial support for private and governmental schools, hospitals, charitable institutions, and NGO buildings, while individuals could not apply for such aid. The amount made available was up to 50% of the total costs of RWH systems, up to a maximum of approximately $800. The smaller amount of the two would be refunded in this case. For 90 RWH systems that were implemented between 2002 and 2006, approximately $76,500 was invested, while about $15,000 were invested for promotional activities (Kumari, 2009).

This was only one of the initiatives of the local government. The Central Goundwater Authority inside the Ministry of Water resources, being aware of the urgent need of a paradigm shift, urged the residential societies, institutions, hotels, industrial establishments, and farm houses located in the notified areas in and around New Delhi to implement rooftop RWH for groundwater recharge by 31 December 2001. If not implemented by this deadline, the existing tubewells would

[8] Delhi Jal Board: ist he government agency responsible for the supply of potable water in the region of Delhi.

have been sealed and the accountables could have been penalized, according to section 15 of the Environment Protection Act of 1986. If the scheme had been implemented as shown by the government, future water shortages would have been avoided (Sharma, 2007).

In the whole area of east Delhi the groundwater is of saline/brakish type. In parallel to urban expansion and growth of urban activities, there was a depletion of fresh water and increase in saltwater levels. In a city that already had around 14 million inhabitants back in 2007, RWH seems to be one of the most feasible solutions to tackle the water scarcity. With 1000 mm rainfall on an annual basis and enough buildings suitable for rooftop RWH, the preconditions are ideal.

For the pilot project implemented in Kishangarh, a district in east Delhi, a household of six people was chosen. The rooftop area of the building was of 150 m^2 on a land area of 900 m^2. The family faced a shortage of 163 l/c/d during the normal season, while things would get worse during the non-monsoon days. The cost of implementation, which did not take account of the land value, was $2,000. The RWH structure has a capacity of 90,000 l. This quantity guarantees a water coverage of 100 l/c/d for 150 days, which corresponds to 28% of the assumed Government of Delhi supply.

Kerala

In January 2004 the municipality of Kerala decided to amend its Building rules from 1999 in order to include RWH systems in new buildings. The amendment, which foresees RWH structures to be included in every new building, was issued by the Government of Kerala. The building categories are divided into the following:

- Residential buildings with a floor area of 100 m^2 upwards and a plot area of 200 m^2 upwards
- Educational buildings
- Hospitals and medical buildings
- Assembly halls
- Offices and businesses
- Specific industrial buildings

The Hindustan Coca-Cola Beverages Case Study in Palakkad (Kerala)

The implementation of the RWH system, carried out by the KRG Rainwater Harvesting Foundation, can now generate approximately 72,000 m^3 of water on the premises of the factory site every year. Before the scheme was realized, the water was just runoff not contributing to any natural percolation as it does now. The project included the construction of three lagoons with a capacity of about33.000 m^3 each and, according to a study, at least 50% of the stored amount percolates into the aquifer. In addition, 25 percolation pits were placed in the surrounding area at strategic locations in order to hold surface water flowing through the open area and through storm water drains, while three bigger percolation pits placed next to the bore wells that were constructed to recharge the deeper aquifer. The water column measured in the wells before the implementation of the project was three meters, while post-project implementation records show that the water column is now eight meters and that TDS dimished passing from 1500 ppm to 1100 ppm.

Thanks to the success of the project, the Coca-Cola Palakkad became a model to follow for the neighboring villages in order to make their wells sustainable by introducing RWH (Gopinath, 2004).

RWH Inclusion in other Regions

Andhra Pradesh: Through the “Andhra Pradesh Water, Land and Tree Act” of 2002, RWH structures became a mandatory provision for all new and already existing residential, commercial buildings, as well as for other premises and open spaces with an area of 200 m^2 or above. In case the provision was not met, the competent authority would implement RWH structures and later recover the costs along with a penalty.

Arunachal Pradesh: Building bye-laws were framed that make RWH compulsory in government buildings.

Bihar: Through the Bihar Ground Water Act (Regulation and Control of Development and Management), enacted 2006, RWH became compulsory for building plans on areas of 1000 m^2 and above (Kumari, 2009).

Gujarat: The Roads and Buildings Department in the city made RWH mandatory for all government buildings. Furthermore, rules were established that prohibit building permit approval if it does not include a RWH structure (Sivanappan, 2006).

Haryana: In 1982 the Haryana Urban Development Authority (HUDA) made RWH obligatory for all new buildings irrespective of the roof area. The Central Ground Water Authority (CGWA) asked all institutions, residential as well as industrial areas around Guargaon Town, to adopt RWH(Sivanappan, 2006).

Himachal Pradesh: Similar to the case described above, RWH structures were made mandatory for all buidlings to be constructed in any urban areas of the state, while building plans not including RWH measures would not be accepted, including schools, government buildings, rest houses, industries, and even bus stands (Kumari, 2009).

Indore (Madhya Pradesh): RWH was made mandatory in all new buildings with an area of 250 m^2 and above. The muicipality offered a rebate of 6% on property tax to implementation of RWH structures (Sivanappan, 2006).

Jharkhand: The State Government started a phased action plan to implement RWH systems in all public and government buildings. Incentives of $400 were granted for the construction of artificial recharge structures.

Madhaya Pradesh: In 2006 a notification by the State Government made RWH mandatory for any building having a plot area above $140m^2$, offering a 6% rebate on property tax to individuals who would implement an RWH system.

Maharasthra: Regulations made RWH obligatory, a building plan not including one would not be accepted (Kumari, 2009).

Meghalaya: The State Government is considering establishing a State RWH Authority (Kumari, 2009).

Mumbai: Again under decree of the State Government, all buildings being constructed on areas equal to orsurpassing 1,000 m^2 must implement RWH (Sivanappan, 2006).

Nagaland: The State Government took provisions making RWH obligatory for all new government buildings.

Pondicherry: Since 2002 the Public Works Department (PWD) of Pondicherry started implementing RWH systems in all governmental buildings and issued rules for the installation of RWH structures in all new constructions.

Punjab: Through amnded bye-laws, all buildings with a surface above 180 m^2 have an obligation to implement RWH systems. A municipal cooperation agreement with Ludhiana and Jalandhar framed by-laws to make RWH compulsory in all new buildings (Kumari, 2009).

Rajastan: In this state, the government made RWH mandatory for all public and establishment properties covering an area bigger than 500m^2 in urban zones (Sivanappan, 2006). Since the beginning of 2006 RWH was made mandatory in state owned buildings with a plot size larger than 300m^2. In case of non-compliance with the rules, punitive measures as disconnection from water supply was undertaken (Kumari, 2009).

Tripura: Since 2004, according to the Tripura Building Rules (Rule-110) RWH became compulsory for all buildings with a plot area of 300 m^2, irrespective of their use.

Uttarakhand: The government issued rules to make RWH systems implementation obligatory and adopted building by-laws in 2003. All development authorities agreed to make partial amendments in the main House Building and development by-laws and regulations in order to achieve this.

Uttarpradesh: Obligatory rules have been established. They include the obligatory installation of RWH structures in all new buildings, schemes and plots, no matter what their use is; RWH has been made mandatory for all new and old governmental buildings.

West Bengal: Vide Rule 171 was included in the West Bengal Municipal Building Rules in 2007, making the installation of RWH obligatory.

Karnataka

The State of Karnataka is the 8th largest in India and the second driest State in the country (after Rajasthan), whereby 20 of its 27 districts suffer from drought and urgently require a solution. Due to a rapid urban expansion, rising pressure was put on infrastructure needs in the city, and the problem of water supply in this case was one of the most urgent issues. In this State 27% of the population (total population is 64 million) depends on bore wells. The status quo further boosts uncontrolled extraction of water, which inevitably further depletes ground water resources.

Rainfall is the only source that replinishes ground water levels, but the terrain slope allows only an insignificant percentage to inflitrate the soil, while the majority of the water runs off. In addition, open spaces in the city are being increasingly covered by roads, pavements, concrete and buildings reducing percolation and constantly reducing inflitration.

The first step to tackle this unsustainable status quo was the creation of a Lake Development Authority for the preservation of lakes and tanks in cities. Karnataka was the first State in India to take this initiative. Being aware that this would not be enough, in 2002 the National Water Policy was adopted. The document states:

- The need to make maximum use of utilizable water resources that are not being exploited. Non-convential methods, such as inter basin transfer and artificial recharge of ground water as well as traditional water conservation measures like RWH and rooftop RWH, have been identified as the means to achieve in increase of utilizable water resources.

- The Karnataka State Water Policy has declared that the efficiency of the use of water resources will be improved and that, in parallel, awareness among the population regarding water being a scarce and precious resource will be raised. RWH as well as water conservation measures will be promulgated through education, regulations, incentives, and disincentives (Draft Policy on RWH, Karnataka, 2011).

As can be seen, the chosen approach is a holistic one involving actors in a top-down process that does not assume a merely imposing aspect.

Karnataka Policy Statement

- In all areas covering municipal and planning boundaries, RWH shall be made obligatory and introduced incrementally.
- The Urban Development Department (UDD) shall ease the development of a State Level Advisory Committee (SLAC), whose duty will be to monitor the RWH implementation process in all its phases at the state level. The committe shall also include a technical cell in order to provide the necessary technical support for RWH systems implementation. The same committee shall be chaired by the Principal Secretary of the UDD and meet at least once every three months to discuss the

status of RWH implementation.

- In order to better monitor the implementation of RWH systems, the UDD shall commit to the task of facilitating the formation of district level RWH committees in every district. These committees shall be formed by representatives from all Government Departments directly involved in urban water management such as the Lake Development Authority, the Central Ground Water Board, the Mines and Geology Department, the Town Planning Department (TPD), the Karnataka Urban Water Supply and Drainage Board; it shall furthermore include two members respectively from NGOs, academic institutions, and field experts. Chair of the committee shall be the responsible Deputy Commissioner of the district. Duties of the committee shall be the preparation, implementation and monitoring of the RWH action plans concerning the city in question. Again, a meeting of the committee shall take place at least every three months to review the status quo.
- Nirmiti Kendras[9] shall be the agencies serving as a vehicle at the district level to provide necessary infomation and assist the

[9] Nirmiti Kendras: are places to train skills in the building sector such as masonry, carpentry, electrical work etc. It is also a place to make cost effective products for this sector such as prefab lintels, windows and so on. Usually it is run by an independent society, but is partyly facilitated by the government in each District of the state.

implementation process as required by the Urban Local Bodies (ULB). It would then be the duty of the Deputy Commissioners to identify further centers taking over the role of link-agencies where Nimrithi Kendras are not present in the locality.

- Required legislations and amendments, togehter with incentives and disincentives, will be drafted to ease and promote the implementation of RWH systems.
- When under their jurisdiction, to identify, demarcate, protect, and maintain water bodies. This will be obligatory for every ULB or Planning Authority (Draft Policy on RWH, Karnataka, 2011).

Considering the formulation of a policy statement, as the one discussed above, one can see how intricate and dense the key factors of the process are. Bringing key actors together, involving independent institutions, making something compulsory (without making it look like an imposition), supporting and monitoring the whole process, and showing presence in the territory through nodal agancies such as the Nimriti Kendras, changing legislative aspects, offering incentives, etc., is a process which needs commitment, political and social will, and active direction steering.

Once the political statement has been given, the distribution of roles and responsibilities is necessary. The State of Karnataka identified the actors – duties relation as follows:

- The SLAC is responsible for framing the State Policy, preparing technical guidelines and manuals, and for monitoring the implementation process of RWH systems.
- The technical Board has to provide the necessary technical knowledge for the manual as well as collect information concerning worldwide trends, current practices, drawings, legislations etc.
- RWH action plans shall be formulated and implemented by the responsible District RWH Committee
- Nimriti Kendras, or the accountable organization, have to provide the needed technical knowledge to the District Committees and ULBs for the realization of RWH action plans.

Implementation Strategy

The selected strategy foresaw a step by step approach to reach effective implementation, and it was structured as follows:

- Considering the topographic, hydro-geologic, and climatic conditions, byelaws shall be introduced and, if necessary, amended within a defined timeframe along with incentives and disincentives to support RWH implementation.
- The TPD shall prepare an Outline Development Plan as well as a Comprehensive Development Plan while emphasizing RWH

both at the building and larger urban area level.

- Publication of RWH guidelines, organization of awareness campaigns, orientation programmes for different stakeholders.
- Implement demonstrative RWH structures on public buildings, educational institutions, parks, open spaces to raise awareness among the different stakeholders.
- The District Level Committees shall formulate an action plan for every ULB, with the technical support of the nodal agencies, for the implementation of RWH.
- Ensure financing and budgetary provisions for the execution of RWH plans
- Identify and preserve all traditional existing water resources
- Include RWH in all future water supply projects in the State.

Stakeholders to be involved in the process

- The totality of households and residents of urban areas
- Private and public education institutions, including research and development centers
- Government and private agencies
- Industrial buildings
- Community Based Institutions (CBOs) and NGOs

Legislative support

- Necessary amendments to the Karnataka Municipalities Act, Karnataka Municipal Corporations Act, and the Town and Country Planning Act as well as the formulation of rules for RWH implementation regarding new and old constructions, such as foot paths, roads, buildings, parks, open spaces, water bodies etc.
- Empower the Karnataka State Pollution Control Board to enforce RWH in all industries operating in the State.

Implementation time frame

- The Action Plan shall be finalized within six months from the date of issue of the State Policy on RWH.
- The ULBs are responsible for the implementation of the respective Action Plans within a period of three years from the date of issue of the State Policy on RWH
- An effort shall be made to implement RWH systems within three years from the date of issue of the State Policy on RWH in all government buildings (Draft Policy on RWH, Karnataka, 2011).

A first step in this direction was that, in those cities with a population exceeding 2 million inhabitalnts, RWH bye-laws had been initiated to make its implementation obligatory. The local Rural Development and Panchayati Rai Department of the Karnataka region, for example, allowed all government buildings and rural schools to implement RWH systems. As incentive the state offered 20% rebate on tax payments for the duration of five years to individual people (Kumari 2009).

Bangalore

Bangalore is the capital city of the region of Karnataka and the sixth most popolous city in India. Its urbanization process was very fast, and this fact challenged the government to build the necessary infrastructures. One of the biggest issues faced by the population is water scarcity and this includes several aspects, such as availability, accesibility, equity, and quality of water, as well as aquifer depletion and groundwater contamination. To provide water to its population, the city draws water from the Cauvery river, located 100km away. The water has to be pumped 500m against gravity, generating electricity costs of about $4 million a month. To tackle the water supply shortage and grant an alternative water supply, the Bangalore Water Supply and Sewerage Board (BWSSB) drilled a large number of bore wells, soon imitated by the citizens. The outcome of this action was the inevitable reduction of groundwater levels, which saw a decrease of 10m between 1978 and 2003.

Although the city relies on ca. 70 rainy days a year, due to poor and meanwhile obsolete urban planning, the drainage system[10] can handle only about 30mm of rainfall per hour. In case of heavy rainfall events, the city hence faces flooding and water logging. Also an important factor is the improper management of the 370 tanks and some major lakes which have disappeared to make way for stadiums, parks, buildings, etc., and leaving no space for water to infiltrate the ground. This often causes storm water to mix with sewage, which is why the BWSSB is working on a plan to implement "zero sewage storm water drains" to avoid this issue.

To act against the status quo, the BWSSB made it a priority to improve water conservation by focusing on RWH. This is meant to partly solve water scarcity on one side, and on the other to mitigate the damage caused by heavy rains (Umamani, 2013).

In view of these urgent problems, the city of Bangalore passed an act in 2009, called "The Bangalore Water Supply and

[10] The water drains of Bangalore were designed about 20 years ago, hence their carrying capacity is the same although the city has expanded drasticaly. Although the BBMP (acronym for „Greater Bangalore Municipal Corporation") possesses the technical expertise to re-design/widen the drainage network, the costs are huge.

Sewerage (Amendment) Act", which was issued by the BWSSB. The above mentioned act made it compulsory to implement a RWH system. Similar to the Chennai case mentioned earlier, nine months after release of the act every owner/occupier of a buidling having an area of ca. 223 m^2 and above, or anyone planning to construct on an area of ca. 112 m^2 and above, had to implement a RWH system and ensure that it would comply with the regulations, so that later the government may recover the costs from the owner/occupier" (BWSSB, 2009).

Conclusion

On one side India was able to achieve vast implementation of RWH systems in many regions of the country that were in need. The Indian policy was well thought out since it united the efforts of the government in finding the right strategies, policies and rebates to offer, with the field work of NGO's that are certainly looked at with less suspicion than bureaucrats. The involvement of a multinational like Coca Cola was also a clever step since the more known a company is, the bigger its sphere of influence will be. The Indian case also shows that implementation can be a fast process, but if it has to be so. It has to be planned carefully in each individual detail, as the Chennai experience shows us. Otherwise all the effort made will carry only half of the potential benefit.

Sri Lanka

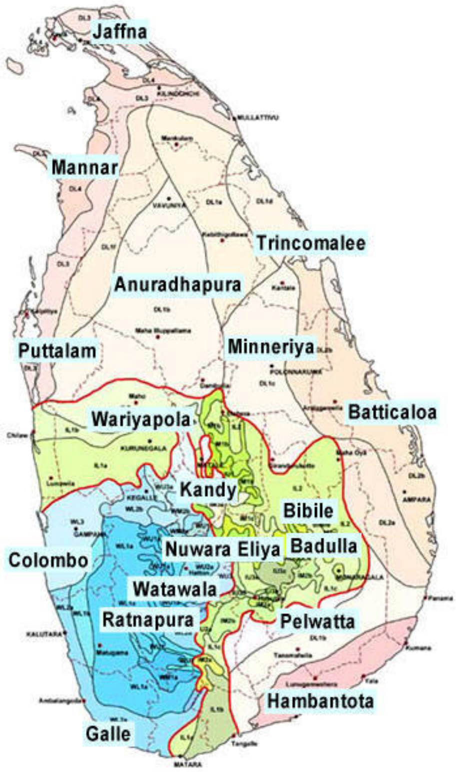

Figure 3, Sri Lanka climatic zones, www.lankarainwater.org, 2014

Introduction

Sri Lanka has, like India, a centenary tradition of RWH use at the domestic and rural level. Back in 1995 this practice was institutionalized under a World Bank (WB) project called Comunity Water Supply and Sanitation Project (CWSSP), which successfully introduced RWH as a water supply option in the districts of Badulla and Matara. The project also gave rise to the Lanka Rain Water Harvesting Forum (LRWHF), an NGO actively promoting RWH in the country. In the last 15 years their work has focused on bringing the concept in an empirical way to all districts by means of demonstration projects, awareness programs, training, research and development, as well as networking (Ariyananda et al. 2010).

Only ten years later in 2005 the government accepted the "National Rainwater Policy and Strategies" (NRPS). In the following the different sections of the policy will be illustrated and commented with focus on the most relevant points for the thesis.

Policy Statement

RWH shall be made mandatory and introduced in phases for certain types of buildings in all areas under municipal and urban jurisdiction within a specified time frame and shall be strongly promoted,. In order to succeed on large-scale implementation of this project, negotiations will be started to facilitate bank loans and micro credit schemes for the provision of RWH systems to house builders. Any investment in this technology would be a longterm investment guaranteeing economic benefits, since economic return is far larger than the investment and maintenance costs.

Aimed Benefits

- Minimize the use of piped potable water for secondary purposes
- Better management of water demand
- Reduce stormwater runoff, avoiding flood damage, soil erosion and land degradation
- Minimize water stagnation causing disesases
- Prevent groundwater depletion through recharge, enhance levels and quantity, minimize water stress during droughts and ameliorate the vitality of all life forms
- Increase decentralized water security and promote operation and maintenance at family level
- Reduce water losses and electricity consumption on a national scale
- Encourage income generation at the rural level and promote urban home gardening
- Planned infiltration to decrease saltwater intrusion and the hazards caused by pollution to traditional water sources
- Reduce the expenditures caused by recurring road-rail maintenance, leading to economic losses as well as remedying the integrity loss of facilities during flooding
- Balance the increase in costs and postpone costly investments to provide piped water
- Meet water needs locally instead of an unsustainable approach transporting water from rural areas to cities
- Commit to reduce urban thermal pollution

- Pledge to achieve the Millennium Goals on water and sanitation
- Grant wider access to additional sources of water during natural disasters as fires, floods, droughts etc.
- Increase domestic water security and decrease unproductive labor, time and risks to which many women and children are exposed when collecting water and transporting it
- Improve access to safe water for marginalized communities

RWH Management Implementation Strategies

- Use the large underground storage capacity to increase the levels of water bodies using known methods such as storage structures, contour bunds, drains etc.
- Issue a document to all interested ministries and agencies to standardize RWH structures in all building designs, to implement it in all government buildings as utility with demonstrative function within a preestablished time frame. In parallel the provincial councils shall commit to raise funds in order to incorporate and monitor RWH in all existing structures having implementation potential, especially if located in strategic positions to raise public awareness.
- Promote RWH on large scale as a cost cutting measure together with the private sector, property developers, Chamber of Construction, industrial estates and investors of the Board of Investments (BOI) projects.

- Cooperate with universities, technical colleges, national institutes of education and health and government training institutions to include RWH in their programs, to train people in the design, construction, research and development, and mainentance of RWH systems.
- Create a group to gather information on worldwide trends, current practices, drawings, legislations, etc. Linkage to global networks is needed to monitor and evaluate policy implementation in order to furnish the collected information to all stakeholders needing such data as well as to train others.
- Use religious institutions as a means to reach people by implementing RWH systems in religious buildings and by cutting the subsidies requested to furnish piped water.
- Create and carry out awareness raising programs for bulk consumers about the economical advantages of RWH for both consumers and the national budget.
- Identifiy and re-establish abandoned RWH collection and storage structures in old government buildings.
- Use the existing facilities of the NGO Forum network together with the knowledge of professionals and new practitioners.
- Publish a "Rainwater Guide for Sri Lanka" intended as mean of support for designers and practitioners, giving design concepts, parameters, layouts, maintenance hints, explaining first flush as well as mosquito and dust elimination system.
- Amend bye laws, identifying rainfall zones and intensities, roof or hard paved areas, micro catchments, permeability and

transmissivity of soils, topography, geological conditions, infiltration ratios etc.

- Change the status of RWH from supplementary to optional water source, in all rural based water supply projects.
- Promote RWH through incentives in the agricultural and plantation sector, helping runoff minimization and helping yields improvement.
- Introduce a budgetary component in every water supply project.

Stakeholders

The stakeholders needed to be involved in the RWH implementation process were identified in all households and institutions, the government and the private entities, lay and religious entities, learning and research centers, as well as industrial and farming establishments (MUDWS, 2005).

Involving such a broad spectrum of stakeholders is surely not an easy task, but it is a necessary one to achieve a holistic approach. The motto followed by the Sri Lankan institutions in creating the NRPS was the famous aphorism uttered by King Parakramabahu the Great (1123-1186) “Not even a little water that comes from the rain must flow in the ocean without being made useful to man”. This sentence expresses a romantic view that does not reflect all the problematics involved in such a process nowadays, but it is a strategic decision to use since it appeals to the historical social identity of Sri Lankans and may hence prove very helpful in rallying support.

Legislative Support

- Amend drainage bye laws created by the municipal council and the Urban Development Authority (UDA) to make RWH a strategy for localized flood mitigation, infiltration facilitation, and improved sanitation in both existing and future buildings. Beside the incorporation of RWH systems in new buildings, the amendment should include the provision of dicounts on the annual rates of the prevoiusly mentiones systems.
- Amendments of bye laws developed by the Road Development Authority (RDA) concerning the construction of roads to allow the building of soft paving and the construction of swales and porous drains to increase sub-soil infiltration.
- Amend the bye laws formulated by the National Water Supply and Drainage Board (NWSDB), to give harvested rainwater an equal status as other traditional water sources in the category of domestic water.
- Amendments to the Apartment Ownership Act concerning rainwater supply, depending on further needed amendments to those made by the UDA and municipal council bye laws (MUDWS, 2005).

Thanks to these projects and initiatives, the Sri Lankans have proved to be very receptive towards water scarcity issues. In 2010, around 30,000 RWH systems were operating in 25 different districts. Large scale projects are being implemented in the urban context, and the trend seems to be increasing in the longterm. This shows how Sri Lanka has started reaping great benefits due to the appropriate use of this technology.

Transferred in an urban context, the NRPS considered which elements account for water consumption at the urban level, observing that water is not only used for drinking, cooking, or washing, but also for gardening, car washing, etc. This consideration showed how the potential for RWH in the city is not merely for drinking water supply purposes, but would also allow the government to save treated water to supply households, while activities not requiring potable water could rely on captured rainwater.

In light of the present constraints faced by authorities in supplying water to an ever increasing number of consumers, the use of rainwater for water supply at the urban level is essential considering the high pipe born water consumption in metropolitan areas.

A study conducted by the government showed how a 34%

reduction of water bills could be obtained by low income hoseholds in Sri Lanka if 30% of the monthly water requirement was met by RWH, while for middle income households up to 61% of the water bill could be reduced by covering the same amount of monthly water requirements (30%) by RWH (Ariyananda, et al., 2010).

RWH has benefits not only on elements directly related to it (less piped water cosumption = lower water bills) but also indirectly, as it reduces the energy consumption and costs related to pumping, reduces flooding, and has the potential to raise groundwater levels in urban areas as well.

During the implementation of RWH systems in Sri Lanka, the problems that were encountered, were solved with the assistance of the University of Moratuwa and the Institute for Construction Training and Development (Ariyananda, et al., 2010), showing how important cross-sectoral cooperation is for mutual benefit.

In the last years RWH was a great aid and proved to be of support during droughts, water scarcity periods, and the tsunami in 2004. Although rainfall is considered high in Sri Lanka, some regions undergo periods of drought. RWH structures implemented in the districts of Hambantota, Moneragala, and Anuradhapura provided rainwater stored in tanks that was available for 5 to 6 months.

If any government desires RWH to be successful with regard to social, economic, cultural, and environmental factors, as with any new concept that is introduced through a top-down approach, the attitudes, perceptions, and behavior of the community need to be shaped. Key factors in this context are awareness raising and training programs in order to reach quality construction, proper operation and maintenance of the systems, management of harvested rainwater, and to change false ideas and attitudes towards RWH. Motivating the community to contribute is very important since it has the effect of increasing the sense of ownership and motivates people towards sustainable management. Of further importance is that the target group has the possibility to supply unskilled labour (which alone provides for almost 15% of the total costs of the system) and local materials. The NRPS underlines how buildings with large roof areas such as schools, government buildings, hospitals, and public places should be used for RWH if sustained by proper institutional arrangements for operation and maintenance.

One of the major problems faced by poor households are the high initial costs. This is why supportive mechanism like loans, incentives, and subsidies should be used to actively and effectively to promote RWH.

The conclusive remark of the NRPS state shows that, even if Sri Lanka at present is not facing pressing water scarcity (except for the areas mentioned above where RWH systems were already implemented), considering the increase of population size, urbanization, pollution of water sources, and climate change in general, such problems may be faced in the future. To adopt RWH now and exploit its potential will help the country to avoid all, or at least many, of these problems (Ariyananda et al., 2010).

Conclusion

It is interesting to see how a country like Sri Lanka, which is not considered among the developed countries of the world, was able to create a policy on RWH including strategies and approaches needed at different societal levels in order to solve problems that are present in some parts of the country, Also of significance is how they included future scenarios planning in the policy in order to anticipate a future inevitable status quo. This farsighted planning is a chance that Lebanon missed, if not in regard to RWH, at least converning water resources and their depletion. Surely Lebanon had to face various events in its recent history that had a major influence on the country and it politics, hence political planning capacity. This is undoubtedbly one of the main reasons for the severe situation affecting water resources in the country nowadays. According to the present and unfortunately accepted situation (at least by the public), the need for action calls for real stakeholders cooperation that would be the first step towards undertaking action.

USA

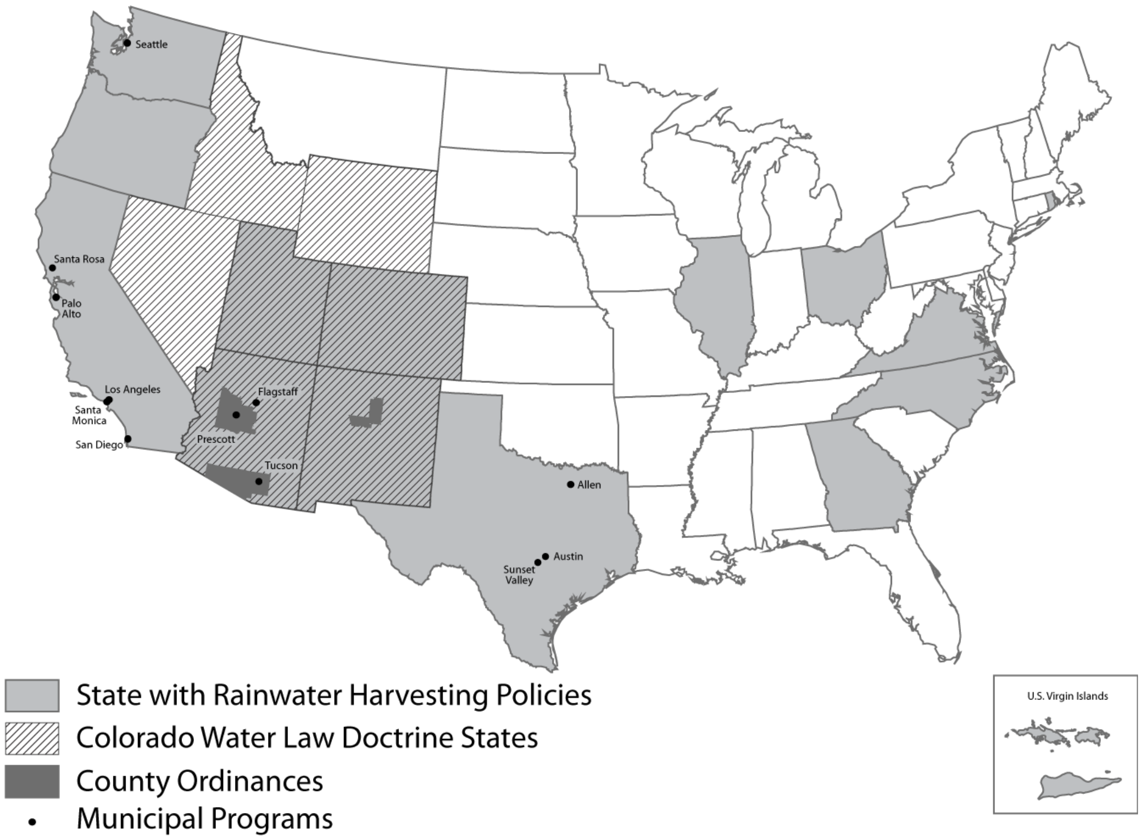

Figure 4, USA RWH policies per country ,Meehan, 2014

Introduction

In the US RWH is a widely used technique whos implementation was supported by governmental, local/municipal policies, legislations, and incentives. Along with Australia and India, the US clearly benefit from a wide and comprehensive approachthat includes stakeholders at different levels to achieve successful implementation of RWH. Below is an overview of the most interesting policies and incentives is provided in order to furnish an overview of the current RWH status in the country.

State of Colorado

The state of Colorado enacted two different house bills regarding RWH in 2009. It is interesting to note that before this date RWH was considered illegal in the state.

The first piece of legislation, “House Bill 09-1129”, determines exemptions for water collected from certain residential rooftops. Point A of the bill states that the Commission Board in cooperation with the State Engineer shall select the sponsors to sustain a maximum of ten RWH pilot projects employing rooftop/impermeable surfaces in residential or mixed-use buildings; the collected water shall be used for non-potable purposes. The purposes of the different pilot projects were identified as follows:

- Quantify the precipitation amount that accumulates in the natural stream system via surface and groundwater.
- Create a database with weather and precipitation patterns in order to study the precipitation duration, frequency, and intensity, as well as water consumption of the vegetation and the return flow amounts.
- Evaluate different RWH system designs.

- Measure the efficiency of precipitation capture (House Bill 09-1129, General Assembly of the State of Colorado).

Point B of the bill establishes the criteria and guidelines for the application and the selection of pilot projects including:

- An application and an annual review fee for the selected pilot projects
- The different information that shall be included in the application, such as a description of the proposed RWH system.
- Paragraphs (incl. 37-92-201) outlining that a range of different sized projects shall be presented for different hydrologic and geographic areas in the state, and highlighting the fact that no more than three pilot projects shall be located within a single water division.
- Prioritization of those pilot projects that are to be located in areas facing renewable water supply challenges and which are promoting water conservation.
- Operation guidelines of the ten pilot projects according to a substitute water supply plan and guarantee that an equal amount of water as the harvested amount be replaced for non-potable uses.
- The handing over of the colleted data after two years of operation to the competent water court to transform the pilot into a permanent project. The aim of the permanent project shall be the use of the harvested rainwater amount for pre-established

purposes. The net depletion shall be calculated as the amount of captured water minus the calculated historical consumption from natural vegetation cover (House Bill 09-1129, General Assembly of the State of Colorado).

Considering the outdated information and data in Lebanon, research, evaluation, and the creation of a database to store all relevant hydrologic information is an important prerequisite prior to the implementation of any new project. Also, any information held by the various stakeholders needs to be incorporated into this database. A spirit of cooperation must overcome the current status quo of fractional conduct. Much attention is given to research in this bill because pilots are the reconnaissance of every successful project.

The second House Bill enacted in the year 2009 was the Bill 09-080. This bill incorporates certain exemptions for water collected from determined residential rooftops, identifying the State Engineer as the authority able to approve permits for specific types of wells and rooftop RWH systems.

- Rooftop RWH is allowed only if a building is used primarily as residence and is not served/connected to a domestic water system that serves more than three single-family dwellings. The intended use for the collected water can encompass exclusively household purposes, fire protection, watering of poultry, livestock, domestic animals as well as the irrigation of a maximum of one acre of garden and lawns.

- A person applying for a rooftop RWH system shall not be required to pay a further application fee in addition to the well permit application fee.
- The property on which the RWH system is to be installed is residential property.
- The landowner uses a well or is legally entitled to make use of one for water supply.
- Rainwater is collected only from rooftops (House Bill 09-080 General Assembly of the State of Colorado, 2009).

It is interesting to note thatthe state of Colorado is considered to be among most restrictives states in the US when it comes to RWH. Nevertheless, they took hold of the opportunity to research RWH systems and their potential benefit.

North Carolina

The General Assembly of North Carolina passed House Bill 609 in the 2011-374 Session. It only makes one reference regarding the practices of RWH, stating that: “The Department of Environment and Natural Resources shall provide statewide outreach and technical assistance as needed regarding water efficiency, which shall include the development of best management practices for community water efficiency and conservation. These best management practices shall address at least all of the following practices […]" under which RWH is mentioned.

Of interest for the research is that the General Assemblystates the imperative necessity for the State to provide $100 million annually to the Clean Water Management Trust Fund in this document. This money is intended to clean up the pollution affecting the State's surface waters and to preserve lands. The duty of allocating grant funds falls to the Board of Trustees and the criteria for grant allocation takes the following issues into consideration:

- Enhancement and conservation of water quality in the state
- The overall objectives of the basin-wide management plans
- Promotion of regional integrated ecological networks
- Targeted areas are environmentally sensitive
- A fair geographic distribution of funds
- Water supply availability to meet essential water uses (House Bill 609 General Assembly of North Carolina, 2011)

For Lebanon, a board of trustees could be formed in the different municipalities, whereas the duty to find/furnish economic support shall be the task of the Ministry of Energy and Water (MoEW), eventually to be shared with other ministries depending on the factors involved, e.g. Urban RWH

– Ministry of Public Works and Transport; RWH on land – Ministry of Agriculture etc.

The North-Carolina House Bill also includes a “Local Water Supply Plan”, stating that all the various units of local government providing public water services, or planning to do so, shall prepare a water supply plan on a local scale and submit it to the relevant department for approval. Technical assistance shall be provided in structuring these plans (House Bill 609 General Assembly of North Carolina, 2011). For Beirut/Lebanon this task could be entrusted again to the individual municipalities that have good knowledge of their respective areas. They should nevertheless be supported by various ministries, in particular the MoEW, that have significant more resources.

Texas

In 2005 the state of Texas published the third edition of “The Texas manual on Rainwater Harvesting”, a document of 88 pages developed by the Texas Water Development Board. This document not only included system components and details regarding water treatment, but also guidelines and possible financial incentives. The parts of this document that are considered relevant to the scope of research are listed below.

Financial Incentives

The Texan legislature passed various bills and some local goverment entities adopted rules providing tax exemptions for RWH systems. Senate Bill 2 of the 77th Legislature, i.e. Texas exempts equipment for rainwater harvesting from sales tax, allows local governments to exempt rainwater harvesting systems from ad valorem (property) taxes.

Financial incentives are not the only method with which the state of Texas tries to make RWH attractive. In this regard performance contracting provisions can be used in the state code to encourage the installation of a RWH system as well as administrative contracting rules for state and local governments (Texas Water Development Board 2005).

There are four main incentives Texas uses to promote RWH:

- **Property tax exemptions** (State-wide): becoming effective with the 77th Texas Legislature in 2001, the Texas Tax Code allows taxing units of the government the option to partly or fully exempt the assessed value of a property making use of water conservation measures from taxation (Texas Water Development Board 2005). When c onsidering the very high value of land in (and the subsequent tax on this value as well), this scheme would be a very interesting incentive for Lebanon.

- **Property tax exemption for commercial installations** (State-wide exemption): Through a constitutional amendment in November 1993 named Proposition 2, equipment for pollution control (incl. water conservation measures) in non-residential buildings is guaranteed exemption from property taxes. RWH systems used in commercial installations are also considered tax exempt. What the amendment wanted to achieve was that the capital invested to comply Environmental rules would not raise the property taxes of a facility. The Texas Commission on Environmental Quality (TCEQ) is the authority that decides whether a facility would get tax exemption or not.
- **County property tax exemptions**: Financial incentives vary from county to county. Hays County is one of the fastest growing counties in Texas and installation of RWH systems here is growing at a rapid pace. A rebate of $100 is offered towards the application fee. Furthermore, if the RWH system serves as the unique source of water for a residence, a property tax exemption is granted (Texas Water Development Board 2005).
- **Municipal incentives**: There are two Texan cities offering financial incentives in addition to the above tax exemption.

These incentives are offered in form of rebates and discounts to residants who install RWH systems.

- **Austin:** The City of Austin Water Conservation Department promotes residential and commercial/industrial RWH. The city sells 283 liters polyethylene rain barrels for $60 each. Residents who buy their own barrels are even eligible for a $30 rebate. In addition, residents may also receive a $500 rebate on the cost of installing a pre-approved RWH system. The application for this rebate includes a formula to calculate optimum tank size and a list of local suppliers and installation contractors. For commercial entities there exists the possibility to receive a $40,000 rebate against the cost of installing new equipment and processes to save water under the Commercial Incentive Program (CIV), while new commercial/industrial sites able to store sufficient water on-site for landscape irrigation may be able to receive an exemption from installing an irrigation meter.
- **San Antonio**: The city offers, thanks to the Large-Scale Retrofit Rebate Program organized by San Antonio Water Systems (SAWS), a rebate of 50% for the implementation of such projects. Up to 50% of the installation costs of water-saving equipment (including RWH) will be refunded to commercial, industrial, and institutional customers. The way the rebates are calculated is by multiplying acre-feet of water conserved by a set value of $200/acre-foot. The installed equipment and the project must be in use for 10 years. SAWS will collect ante/post

retrofit installation water use data in order to establish if the set conservation goals are met. An engineering proposal and the results of a professional water audit showing expected savings needs to be handed in, the return on investment is shortened by the rebate (Texas Water Development Board 2005).

Furthermore, in 2011 House Bill 3391 grants loans for buildings with rainwater as the sole source; while in 2013 House Bill 2781 stipulated the use of RWH systems for potable and non-potable uses along with public water supplies. The same year another law, House Bill 4/1025, was enacted providing $2 billion for water projects including $400 million for water conservation and reuse (Krishna, 2013)

Case Studies

J.J. Pickle Elementary School/St. John Community Center Austin

In the city of Austin, Texas, the J.J. Pickle Elementary and St. John Community Center implemented a model of sustainable design and building. The project was the outcome of the cooperation between the Austin Independent School District and the City of Austin.

The facility lies on an area ca. 10.800 m^2 large and the water falling onto it drains into three tanks. The captured water is then used for cooling purposes of the air-conditioning system. Together with RWH, solar panels are used to reduce electricity costs in parts of the building and the City library. Opening in 2002, the complex now saves $100,000 a year (operational and maintenance costs). The construction costs were $13.6 million, of which ca. $8.3 million was funded by AISD and $5.3 million by the water collected from the rooftop (Texas Water Development Board 2005).

Medical Office Building, Webster, Texas

This structure is built on a catchment area ca. 1350 m^2 large including the roof and the parking area used for storm water management, with a total storage capacity is of ca. 662 m^3. The green roof of the building has two main functions: to absorb rainwater and to cool the building. In fact 90% of the rain falling on the catchment area is collected and consequently used for landscape irrigation and restroom uses.

Besides being an example of integrated urban planning, uniting RWH to energy savings enabled property owner to save $125,000 since there was no need to build a retention pond and in the long run it was proven that the water and energy savings would amount to approximately $350,000 (Krishna, 2013).

In November 2006 the Texas Rainwater Harvesting Evaluation Committee (TRHEC) provided a report to the 80^{th} legislature on RWH potential and guidelines for Texas. These guidelines are divided into area of interest and include key findings and recommendations with a list of final recommendations Texas Rainwater Harvesting Evaluation Committee 2006.

Potential of RWH in Texas

The main key finding in this regard is that the State of Texas has great potential for RWH, which is considered a reliable and economical source of water. Furthermore, no costly distribution systems are needed since the product RWH is used localy (Texas Rainwater Harvesting Evaluation Committee 2006).

Recommendations to promote and expand RWH

- Direct new state facilities with a roof area of 930 m^2 or more (also facilities with smaller roofs when feasible) to implement RWH systems into buildingdesign. Harvested rainwater may then be used for toilets and landscape watering purposes.
- Develop a program of incentives to promote the incorporation of RWH systems in the design/building of new residential, commercial, and industrial facilities.

- Take into consideration a biennial appropriation of $500,000 to the TWDB for matching grants to be used for RWH pilot and demonstration projects in Texas (Texas Rainwater Harvesting Evaluation Committee 2006).
- TCEQ should consider exempting homes with RWH systems from water quality regulations
- Include RWH systems as Energy Star[11] products to receive federal tax credits, which would potentially cover up to 30% of the costs (Krishna, 2013).

Guidelines, Standards, and Regulations

New legistlation is the main focus here. Considering the possible reduction peak demands through its implementation, the reduction of storm water runoff (very important for Lebanon), non-point source pollution, and erosion in urban environments, following points must be considered:

- Direct the TCEQ as well as other state agencies to continue exempting those homes using RWH as their sole source of

[11] Energy Star: this is an international standard for energy efficient consumer products which was originally developed in the USA and then adopted by other countries such as Japan and the European Union.

water supply from various water quality regulations that might be imposed by public water systems. In case this might be considered a valid option for Lebanon, guidelines to assist homeowners to improve and maintain the quality of RWH for out- and indoor uses should be provided.

- Facilities using public water supplies as well as RWH for indoor purposes should be required to have standardized cross-section safeguards and to use harvested RW only for non-potable indoor purposes. The TCEQ and other state agencies involved in the field will be responsible for achieving this.
- Grant $250,000 to the Texas Department of State Health Services to conduct a study on public health epidemiologic effects and a laboratory study to assess pre- and post-treatment water quality coming from different types of RWH systems across the state and prepare a report to be submitted.
- Encourage different Texan cities to enact ordinances requiring that their permitting staff and building inspectors have more knowledge about RWH systems, and to allow the implementation of such systems in private households and other buildings if properly designed (Texas Rainwater Harvesting Evaluation Committee 2006).

Training, Education, and Certification

The key finding here was the need to develop training and educational materials on RWH in order to design suitable systems and to fully exploit the potential of RWH in Texas. A successful and widespread integration of RWH systems with public water systems clearly needs commitment on the part of state and local governments through development of professional programs, training; ergo all necessary education opportunities as well as certification on RWH systems. In Texas there is still lack of regulation in this regard, especially in the areas of: 1) lack of certifications or licenses to design, install, and maintain RWH systems and 2) training conducted by the TSBPE (Texas State Board of Plumbing Examiners) for licensed plumbers and water utility operators that includes information on RWH systems. The following points were identified as relevant for improving professional service capabilities of RWH consultants, contractors, and local governments. The legislature should consider:

- Enhanceing cooperation between the TCEQ and the TSBPE in order to develop a certification program for RWH installers and provide ongoing education programs.
- Encouragment of the Texas Cooperative Extension to expand programs for training and information dissemination that includes RWH for indoor uses.

- Involvement of Texan institutions of higher education as well as technical colleges to develop programs and provide instruction on RWH technology (Texas Rainwater Harvesting Evaluation Committee 2006).
- Training led by Texan Agri-Life[12].
- Development of RWH courses by various colleges and universities (Khrisna, 2013).

There were other suggestions at the end of the document drafted by the TRHEC, of which only the following are considered as potentially interesting for the scope of research:

- State agencies should develop and include all the specifications regarding design and installation for RWH systems in the Texas Building Code and Energy Performance Standards.
- Passed in 2001 under Senate Bill 2, all local taxing entities in the state should consider fully exempting the cost of RWH equipment from being added to the value of any commercial, industrial, or residential property when it comes to property tax assessment.

[12] Texan Agri-Life: It is the agricultural and life sciences research agency of the Texan State.

- Cities and local taxing entities should consider changing their land development regulations in order to exempt rooftops used for RWH from being considered as impervious cover.
- Cities, local communities, and the Texas Cooperative Extension should raise awareness of sales tax exemption for RWH equipment and supplies.
- Workshops and local meetings should be organized by cities to bring together their permitting staff, architects, engineers, builders, and mortgage lenders to promote RWH for commercial, industrial, and residential buildings through a community based effort.
- Regional water planners should promote RWH as a source of alternative water supply.
- RWH projects shall be considered for funding (depending on eligibility) by local economic development corporations.
- In order to encourage others to adopt RWH, cities should recognize and provide awards to facilities using the best RWH techniques (Texas Rainwater Harvesting Evaluation Committee 2006).

Other US States and Cities

The State of Ohio has the most extensive rules on rainwater harvesting in the United States, including codes govering cistern size and material, manhole openings, outlet drains, overflow pipes, fittings, couplings, and even roof washers. Ohio's rules also address disinfection of private water systems.

The City of Portland has, for example, approved supplemental use of public utility water at private residences since 1996. The code includes specific guidance on the design and installation of the system. It also limits rainwater to non-potable uses. The Portland Office of Planning and Development publishes a RWH Code Guide, which includes FAQ and the relevant code sections (City of Portland, 2000). In 2002, the State of Washington Building Codes Council developed guidelines for installation of rainwater harvesting systems at commercial facilities.

Santa Fe County, New Mexico, passed the precedent-setting regulation requiring rainwater harvesting systems on new residential or commercial structures of 232 m^2 and larger.

Overview of the most important RWH policies, guidelines, and codes in the US

- **Tucson**, Arizona: By June 2010 all commercial activities must harvest RW, be it active or passive, for a complex amount equal or greater than 50% of the landscape irrigation. This was a Bill passed in 2008 and allows non-potable use of harvested RW for indoor as well as outdoor. The incentive was $300 per implemented RWH system.

- **San Francisco**, California (City and County): Also in 2008, a MOU (Memorandum of Understanding) was passed to encourage safe collection, storage,and use of harvested RW for non-potable uses without treatment to potable standards. In 2012 a Draft Ordinance under Article 12C was passed, establishing regulations for the use of alternative water sources, including RW, for non-potable purposes. This draft ordinance is meant only for large residential and commercial buildings.
- **Utah**: Senate Bill 32 states that beginning May 11, 2010 collection and use of RW is allowed without obtaining a water right after registering on the Division of Water Rights web page (no registration fee). The storage is limited to a single underground container of 9465 liters or to two above ground containers of 380 liters each. The rainwater can be collected and used only on the part of land owned by the collector (ARCSA, 2012,).
- **Washington**: In 2012 the Energy and Water Research and Integration Act was passed. It directs the Secretary of Energy to integrate water issues into the Department of Energy's research. The Act imposes the use of technologies and practices to guarantee the minimization of fresh water withdrawal and consumption, to increase the efficiency of water use as well as the use of non-traditional water resources, with the objective of improving water quality. The bill states that the responsible person for the development of a strategic plan is the Secretary, who is also in charge of creating the necessary technical

landmarks to address the Energy-Water Nexus. For the research the Act grants $300 million over five years, establishing an Energy-Water Architecture Council to help coordinate and promote a better collection of energy and water data (Hansen, n/a).

Conclusion

In USA many bills and acts were enacted in order to make RWH compulsory. Generous research funds were granted to explore the potentials of RWH on the technical and implementation level, but also to collect the various energy and water data needed to further develop strategies. Tax exemptions of different kinds were also a means to make RWH attractive for the public. The information that could be gathered in the USA is surely not complete since access to information is difficult. Nevertheless, the most important legislation pieces and incentives were included.

Jordan, Palestine and Israel

For the scope of the master thesis it would have been interesting[13] to see what kind of policies, legislations, and incentives for the promotion of RWH were implemented by the nieghbours of Lebanon. During the research I conducted, I was unfortunately not able to find information about the enforcement of such strategies on political-economic level, despite the fact that RWH practices are well known and used at least in Jordan and Palestine.

In some arid regions of Jordan RWH was the only way to secure fresh water until well drilling and piping were implemented starting back in 1940. Fresh water for domestic use hence relied completely on rainfall (Abu-Zreig, et al., 2012).

A research conducted by professionals in cooperation with the Jordan University of Science and Technology and the

[13] Intersting but not obligatory, since pragmatically incentives are not strictly related to the climatic reality of a country. Considering this fact, if they were implemented further away or not, it would not have direct implications on their validity. Nevertheless it would be very interesting to see the implementation of such strategies in neighbouring countries since this would mean having concrete examples of such strategies in countries with similar constraints, hence possibly facilitating this kind of transition.

Department of Land, Water, and Environment at the University of Jordan showed the importance of RWH for climate change adaptation and the increase of population in the country. RWH was identified as one of the main solutions in this regard and the need for a country wide integrated approach for the promotion of such techniques at national level was promoted. About 6% (14.7 MCM) of the total annual domestic national water supply could be covered this way. In light of the severe water problems faced by Jordan, the adoption of awareness campains as well as financial and technical programs to foster and support the implementation of RWH systems is recommended (Abu-Zreig, et al., 2012).

Jordan's Water Strategy 2008-2022 described in the section entitled *Water for Life* the implementation of regulations as incentive structures to foster RWH, and the inclusion of RWH in the codes and requirements of buildings is stressed and repeated through all the document. However, it was not possible to find documents detailing strategies to include RWH tools at the legal level, although it is known that Jordan made the inclusion of RWH systems mandatory for new buildings at national level.

The need for action in this regard becomes even clearer when we look at simple statistics that only 5% of rainwater is currently being used in Jordan while 85% is lost through evapotranspiration and the remaining 10% through runoff.

For Palestine and Israel the story is different since Israel has restrictive measures about RWH, although the government is thinking about changing these restrictions, while in Palestine RWH is partially used since it is an essential need, considering that the water supply lies in the hand of Israel. In Palestine no incentives are offered and there are no regulations for RWH, the main constraint is undoubtedbly the political situation which extends its reach to water resources.

Conclusion

The overview offered in the thesis showed RWH implementation strategies in four countries: Australia, India, Sri Lanka, and the USA. Incentives and rebates were shown to be the best means when promoting RWH implementation. Attractive legislation and policies were illustrated and commented to showcase the foundations on which such change can lean on. Due to time constraints and the difficulty in sourcing suitable material, it was not possible to include an analysis of RWH in other countries. I made the decision to focus on these countries because they have vast and inclusive RWH strategies. Their present legislations and incentives are hopefully conducive for the purpose of guiding Lebanon if and when RWH gets on the country's agenda in the future.

RWH systems cannot be easily implemented in places having specific dynamics (fast and continuous change/expansion) or distinguishing characteristics (concrete cover, vertical building, concentrated pollution) as in cities, this is undeniable. This is why, especially at this very moment in Beirut and overall in Lebanon, integrated urban planning must be an integral part of an IWRM approach in shaping a strategy as well as during the implementation process.

In the thesis, it is possible to see how RWH was made compulsory in many regions of various countries and while making it obligatory, incentives and rebates were offered to make this change seem less of an imposition. Some amendments were made to existing laws to include RWH, e.g. in building laws, but also entire RWH legislation pieces were created as in the case of Sri Lanka. All the discussed countries had nevertheless something in common, RWH was never contemplated as “water to save water” alone. RWH was always linked to other aspects that are undoubtedly strictly related to water, although too often are taken for granted. In fact, when talking about RWH, electricity is inevitably mentioned (less energy consumption, environmentally friendly, less costs) as well as the possibility of avoiding investments in so called mega-projects such as the construction of dams or urban flooding prevention systems. The name might be misleading but RWH is not only a technique to collect water for private use, its benefits go far beyond it.

The Lebanese government should be ready to grant at least $433 million per year for RWH research and other alternative water supply measures since this is the amount of money the Lebanese government loses every year due to its passivity in the water sector. The specific cost of inactivity in this sector is calculated to be around 2.8% of the GDP/y, of which 70% are opportunity costs, hence mostly funds invested by private households to compensate the tap water shortage. With this in mind, it would be advisable to create an experts panel working on the untapped potential of RWH. The experts panel should include stakeholders from diverse institutions and having heterogeneous backgrounds, among these I would identify: two delegates of the MoEW, one representative respectively from the Ministry of Environment, the Ministry of Finance, the Ministry of Public Works and Transport, and the Ministry of Health, one or two representatives per NGO working in the Lebanese water sector (e.g. Mercy Corps, CHF international etc.) who are interested in cooperating on such a project, two experts in integrated urban planning, two engineers with experience in RWH systems implementation, and two plumbers with experience in RWH systems. The expert panel could also include a maximum of four other experts with different academic backgrounds, such as economics or management. It is important to underscore that when I say "representative" or "delegate", I don't mean someone working exclusively in the name of an institution and trying to achieve specific benefits for the institution. What is needed is someone to bring the institution's and one's own expertise thereby putting it to effective use for this experts panel.

The task of this expert panel would be to identify the feasibility of (among others) RWH systems in the city of Beirut and the greater Lebanon area. The first step has to be the collection and sorting of all the data and information about hydrology, geology, weather, etc., of which at present too many different stakeholders are in possession, and to determine which further data may be needed. Afterwards national guidelines must be set and a strategy sketched out. Cooperation with public institutions such as universities, technical colleges, etc,. will be needed in order to include RWH in their curricula and also to entrust some RWH pilot projects to them in order to evaluate their practical feasibility. Religious institutions should be also included in this process since they have the power to reach the vast majority of people and to publicize RWH systems through implementation in religious buildings. Only at a later stage, when the feasibility of RWH will have been tested, not only in economic terms but also by raising citizen awareness, should financial incentives will be offered. Once more it is fundamental to highlight how the community-given-value of water has to reflect the real value of this good since there often is a discrepancy between them.

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Appendices

Agency	State/Country	Bill, Code, Guideline, Incentive, Policy, Recommendation	Content	Year	Harvesting Surface	potable/ non-potable use	Related Case Studies	Implementation constraints	Urban/Rural area	Size and type of building
USA										
Commission Board/State Engineer	Colorado	House Bill 09-1129	Tax exemption for RW harvested from certain residential rooftops Pilot projects to be iplemented in areas facing water supply problems	2009	rooftop	non potable	n/a	none	urban and rural	residential and mixed use
Commission Board/State Engineer	Colorado	House Bill 09-080	RWH is allowed only if the building is not connected to any domestic water supply system, residential property. No additional application fee to the well application fee shall be applied.	2009	rooftop	non potable	n/a	none	urban and rural	not specified
Department of environment and Natural Resources	North Carolina	House Bill 609	$100 MLN to be provided yearly for the Clean Water Management Trust Fund to clean up pollution, conserve and enhance water quality and meet essential water demand.Assistance for RWH systems implementation shall be provided by the department	2011	n/a		n/a	none	n/a	not specified
Government	Texas		Property tax exemptions, property tax exemptions for commercial installations, county property tax exemptions, municipal incentives	1993 to 2001	rooftop	non potable	Austin and San Antonio. Medical ofice building Texas, J.J. Pickle Elementary School St. John Community Center Austin. See pp.77-80	none	urban and rural	not specified
		House Bill 3391	Loans for buildings with RW as the sole source of water	2011	rooftop				urban and rural	not specified
		House Bill 2781	Use of RWH systems along public water supplies for potable and non-potable use.	2013	rooftop	potable and non-potable			urban	residential
		House Bill 4/1025	$2 BLN for water projects (including RWH) and $400 MLN for	2013	different	non-potable			urban and rural	not specified

			water conservation and reuse							
Government	Tucson, Arizona	Bill	All commercial activities must harvest RW for a complex amount of at least 50% of the water used for landscape irrigation. $300 per implemented RWH system were offered.	2008	different	non-potable	n/a	none	urban	not specified
Government	Utah	Senate Bill 32	Starting may 2010 RWH is allowed without any registration/application fee needed. RW storage limited to 9460 liters underground or 760 liters above. Collection and use of the water only possible on the property of the collector	2010	rooftop	non-potable	n/a	none	urban and rural	not specified
Government	Washington	Energy and Water Research and Integration Act/Bill	Use of technologies and practices to to minimize fresh water withdrawal and conspumption, improve water quality and increse efficiency of non-traditional water resources.$300 MLN over five years were granted to achieve these results	2012	different	non-potable	n/a	none	urban and rural	not specified

INDIA										
Agency	State/Country	Bill, Code, Guideline, Incentive, Policy, Recommendation	Content	Year	Harvesting Surface	potable/ non-potable use	Related Case Studies	Implementation constraints	Urban/Rural area	Size and type of building
Tamil Nadu Government	Chennai	Law	RWH systems implementation obligatory for all existing until october 2003 and future buildings	June 2003	rooftop	non-potable	The Sundram Fasteners LTD (SFL). See p.36	only 50% of RWH systems were implemented efficiently	urban	not specified
Delhi Jal Board	Delhi	Bill	Subsidy scheme to sustain RWH systems implementation in schools, hospitals,	2004	rooftop	non-potable	n/a	none	urban and rural	non private buildings

			charitable institutions and NGO buildings. Refund of 50% of expenditures up to $800							
Central Groundwater Authority	Delhi	Bill	Would the required building not implement RWH for water supply and groundwater recharge by December 31st 2001, tubewells coud be sealedand accountables be sued	May 31st 2001	different	non-potable	Kishangarh see p. 39	none	urban and rural	residential societies, institutions, hotels, industrial buildings
Municipality of Kerala	Kerala	Amendment of building codes	Include RWH systems in every new residential buildings with floor area of 100 m2 up and a plot area of 200 m2 upwards, educational buildings, hospitals, offices and businesses, industrial buildings	2004	rooftop	non-potable	Coca-Cola Beverages Palakkad. See pp.40-41	none	urban and rural	residential
Local authority	Indore	Law	RWH made mandatory for all buildings with an area of 250 m2 and above. 6% rebate on property tax offered as an incentive	n/a	rooftop	non-potable	n/a	none	urban and rural	not specified
HUDA	Haryana	Law	RWH made compulsory for all new buildings	n/a	rooftop	non-potable	n/a	none	urban	not specified
Government	Rajastan	Law	RWH made compulsory for all public properties covering an area bigger than 500 m2 in urban areas	n/a	rooftop	non-potable	n/a	none	urban	public
Government	Mumbai	Decree	RWH made compulsory for all new	n/a	rooftop	non-potable	n/a	none	urban	not specified

			buildings being constructed on an area of 100ßm2 or above							
Roads and Buildings Department	Gujarat	Decree	RWH made obligatory for all government buildings. Every future building plan must include a RWH system	n/a	rooftop	non-potable	n/a	none	urban	governmental buildings
Government	Andhra Pradesh	Andhra Pradesh Water, Land and Tree Act	RWH systems made compulsory for existing and future buildings and open spaces with areas of minimum 200 m2. In case of non-compliance with the disposition, the competent authority would implement the RWH system and later recover the costs along with a penalty	2002	different	non-potable	n/a	none	urban and rural	residential, commercial buildings and other premises and open spaces
Government	Himachal Pradesh	Decree	RWH made compulsory for all buildings to be constructed in a urban area. All building plans have to include a RWH system	n/a	different	non-potable	n/a	none	urban	schools, government buildings, rest houses, industries and bus stands
Government	Karnataka	Decree	Creation of a Lake Development Authority to preserve lakes in the region and creation of a National Water Policy	2002	different	non-potable	n/a	none	urban and rural	not specified
Government	Bangalore	Water Supply and Sewerage Act	RWH provision made compulsory	2009	different	non-potable	n/a	none	urban and rural	not specified

			in existing and new buildings. System purchase and implementation costs to be refunded by the government							
Government	Madhaya Pradesh	Decree	RWH made compulsory for all buildings having a plot area over 140 m2. 6% tax reabte were offered	2006	rooftop	non-potable	n/a	none	urban and rural	not specified
Government	Maharasthra	Regulations	RWH made compulsory for all buildings. Any building lpan not including a RWH system would not be accepted	n/a	rooftop	non-potable	n/a	none	urban and rural	all building types
Government	Nagaland	Decree	RWH made compulsory for all new government buildings	n/a	rooftop	non-potable	n/a	none	urban and rural	governmental buildings
PWD	Pondycherry		Implemenetation of RWH systems in all governmental buildings and RWS systems installation rules were issued (for new constructions)	n/a	rooftop	non-potable	n/a	none	urban	governmental buildings
Government	Uttarpradesh		RWH systems made compulsory for all new and old government buildings and all new buildings, schemes and plots no matter what their use is.	n/a	rooftop	non-potable	n/a	none	urban	governmental buildings
Government	West Bengal	Vide Rule 171	RWH made compulsory for all buildings	2007	rooftop	non-potable	n/a	none	urban	not specified

Government	Pujab	Bye-laws	RWH implementation in all buildings with a surface of 180 m2.	n/a	rooftop	non-potable	n/a	none	urban	not specified
Government	Jarkhand	Decree	RWH systems implementation in all public and government buildings. $400 offered for the construction of artificial recharge structures	n/a	different	non-potable	n/a	none	urban	not specified
Government	Uttarakhand	Decree	Building bye-laws adopted and RWH made compulsory in all buildings	2003	different	non-potable	n/a	none	urban	not specified
Government	Tripura	Decree, Tripura Buidling Rules, rule 110	RWH made compulsory for all bildings with a plot area of 300 m2 irrespective of their use	2004	different	non-potable	n/a	none	urban	not specified
Government	Bihar	Bihar Ground Water Act	RWH made compulsory for building plans aon areas of 1000 m2 and more	2006	different	non-potable	n/a	none	urban	not specified

AUSTRALIA										
Agency	State/Country	Bill, Code, Guideline, Incentive, Policy, Recommendation	Content	Year	Harvesting Surface	potable/ non-potable use	Related Case Studies	Implementation constraints	Urban/Rural area	Size and type of building
Government	Victoria	Victoria Water Rebate Program	Rainwater tank rebates $850 for 2.000 to 2.999 liters, and $1.300 to $1.500 for 4.000 liters or bigger. In both cases only if tank was connected to toilet/laundry. Small businesses could apply for a total	2012	different	non-potable	Queensland and NSW, see pp.22-24	none	urban and rural	different

			$2.000 rebate for selected RWH products							
NSWCCF	NSW	Policy	$123 MLN per year to save 19.8 BLN of liters per year and $49 MLN in water bills per year. RWH tanks rebates of $150 for 2.000 to 3.999 liters, $500 for 7.000 liters or highercapacity, plus $500 if the tank is connected to the toilet/washing machine. Schools were etitled to $2.500 for RW tanks installation. $150 incentive for the purchase of a 5-star water efficiency washingmachine	2011	different	non-potable		none	urban and rural	different
Government	Western Australia	Rebates	Rebates for three different types of toilets were offered costing between $385 and $600. Two types of RWH tanks were offered, both having a 2.000 liters capacity costing $1.150 or $1.750	2014	different	non-potable		none	urban and rural	different
SRI LANKA										
Agency	State/Country	Bill, Code, Guideline, Incentive, Policy, Recommendation	Content	Year	Harvesting Surface	potable/ non-potable use	Related Case Studies	Implementation constraints	Urban/Rural area	Size and type of building
Ministry of Urban Development	Country wide	National Policy	Strategies to minimize piped water use,	2005	different	potable and non-potable	n/a	none	urban and rural	different

and Water Supply			diminish stormwater runoff, reduce water and energy consumption at national scale, and identify stakeholders and cooperation partners							

Abstract in Arabic

المياه ندرة من تعاني التي المناطق في بالماء التزود لضمان ذلك و قصوى اهميه ذات الامطار مياه تجميع برك تعتبر
كيف هو المطروح السؤال أن غير مستعمله غير مائيه برك به بلد ولبنان .المائيه للموارد الرشيد الغير الأستعمال أو
للوسائل العمل هذا في التطرق سيتم ؟ الجميع على بالنفع ودليع واسع نطاق علي المائيه الموارد هذه استغلال يمكن
وسوف والاعانات القروض الضريبيه؛ والأعفاءات ؛ اللوائح و القوانين بينها ومن وتحليلا عرضا المرتبطه القانونيه
قاسماً تعرف البلدان ذهه .المتحده والولايات وسريلانكا والهند أستراليا وهي المجال هذا في رائده دول باربع الاستدلال يتم
الوسائل كل سرد فهو الأطروحه هذه من المتوخى الهدف أما .أخرى بخصائص تنفرد أنها غير الظواهر بعض في مشتركاً
من مناسبه اجراءت اتخاذ فعليه المجال هذا في فرصته من حد لاقصى لبنان يستفيد ولكي القطاع تنظم التي القانونيه
دراسه مسؤوليه عاتقها على ستاخذ والتي المختلفه المؤسسات كل عن ممثلين من مكونه عخبرا مجموعه تكوين بينها
.المتوخاه الأهداف تحقيق امكانيه تبين عمل استراتيجيه وايجاد المشكل

Declaration in lieu of oath

By

Niccolò Parigini

This is to confirm my Master Thesis was independently authored by myself, using solely the reffered sources and support.

I additionally assert that this Thesis has not been part of another examination process.

Beirut 15.12.2014 Niccolò Parigini