Systems Thinking makes you Wise, System Dynamics helps you test your Wisdom

Mihir Mathur

Kartik Bitra

DESTA Research LLP

New Delhi

Paper Selected at the ISDC 2024 Conference

Contact: mihir@desta.co.in

Abstract

There have been many instances where applying systems thinking has helped individuals and groups of people gain insights about the problems that otherwise would have been difficult for them to realise. The power of systems thinking comes from allowing people who understand parts of a system to map the interactions and then contemplate the outcomes these interactions are producing. These outcomes could sometimes be counterintuitive and hence often not easy to understand by just studying the parts in isolation. Applications of group model building, participatory systems thinking approaches and community-based system dynamics have shown success in helping people better understand key systems structures responsible for producing the dynamic behaviours as observed in the real world. But is that enough to allow people to identify and design new system structures for it to produce the desired behaviour? In this paper, through the use of real-world case, I demonstrate that applying systems thinking makes people gain wisdom about the systems structure and the reasons for their counterintuitive behaviour. However, it does not allow them to effectively test their wisdom by answering specific questions. It does not allow them to test the sensitivity of alternate policy design or interventions, decide new targets or the extent of changes required or help in calibrating the intervention. Systems thinking done without the use of system dynamics can often lead to people moving towards enlightenment, thinking systemically and asking systemic questions. But then are left high and dry searching for more answers. The use of system dynamics becomes necessary at this stage for them to move towards actionable insights and thus must always be applied together with systems thinking. Applying systems thinking would likely make people gain wisdom but not always allow them to test their newly gained wisdom. System Dynamics can fill that gap to an extent and thus must be applied together with systems thinking to create a higher impact.

Introduction

Systems thinking is becoming a growing necessity for organizations, individuals and groups of people who wish to create a positive change. The modern world has become increasingly interconnected and it is not possible anymore to think about interventions in isolation (Sterman 2000). Each activity is bound to create cascading impacts over time and space in ways known and unknown to us. The time delays involved in the outcomes only complicate matters further by impairing our learning about the interventions that we do (Sterman 2000). The plastics drained down the sewage over decades are now showing up in the food we eat in the form of microplastics in salt and fish (Alberghini et al., 2023). The evidence of harm is now visible but only after a long time delay. Hence, formal applications of systems thinking and system dynamics modelling must be done to better test the first-order and far-fetched effects of our actions and more importantly before designing interventions or policies in the real world.

There has been an uptake of systems thinking and modeling in the recent past in India. Increasingly organizations are talking about it and using the approach in their strategy and operations. This has been observed in the development sector – like philanthropies, NGOs, think tanks, foundations and Section 8 companies. DESTA has been working with such organizations since its formation in 2018 and has engaged with them in over 30 projects. The learnings accumulated have helped improve the application process for systems thinking and system dynamics modelling. With each round of iterative learning, the uptake has also increased showing indications of success. There are more commercial opportunities than there were a decade ago. The majority of these opportunities have been revolving around the application of systems thinking. The use of qualitative mapping and group modelling has enabled organizations to think through their strategy, theory of change and program

design. Finding adequate utility some organizations have created a long-term vision of mainstreaming systems thinking into their organization as a practice. This has created a ripple effect in the sector and attracted more organizations to do the same.

With all the success of systems thinking there are some growing concerns about what happens after systems thinking is applied. How would people and organizations use all the wisdom gained to create changes in their interventions and policy design? This has been the burning question that has often been asked after the successful application of systems thinking by the clients. The answer is to move towards system dynamics modeling which can help in answering specific questions for designing interventions or policies. Systems thinking done without system dynamics runs the risk of making the process incomplete and leaving people high and dry searching for answers to more systemic questions. In the long run, this could turn counterproductive for the growth of this field. In the below section, we demonstrate an example to bring home the point of why systems thinking runs the risk of becoming an incomplete science to answer specific questions in the absence of using system dynamics. This example is a case in point and not an exhaustive case study in itself.

Successful Case of Applied Systems Thinking

In the year 2018, a group modelling workshop was conducted for a group of Non-Governmental Organizations that work on a non-profit basis to improve the lives of female survivors of domestic violence. The objective of the workshop was to be able to map the system of domestic violence to be better able to engage with the problem and identify more areas of intervention. Over two days the mapping exercise was conducted and a multi-causal loop diagram was created having more than ten loops. The diagram represented portions of the collective learnings and experiences of the group of participants who have been working with survivors of domestic violence for many years.

One of the key problems articulated was that even after decades of work the issue of domestic violence had not receded, in fact, some observed that it might have increased. This got everyone curious about the reasons for this especially since the overall project funding and the number of projects trying to work on solutions have been increasing over time. The dynamics hypothesis of this problem behaviour is shown below.

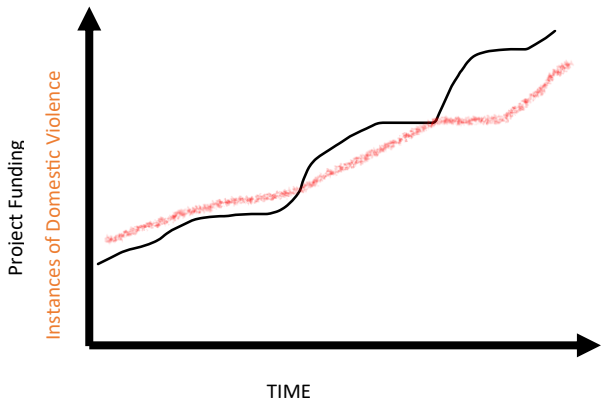


Figure 1 Behaviour Over Time Graph of the extent of project funding and instances of domestic violence

The above graph shows the pattern in the increase of project funding given for solving the problem of domestic violence and the increase in the instances of domestic violence. The patterns are only indicative and do not explain the quantum of change. It just reflects the dynamic nature of the

problem that even with more funding and several projects the problem has not been solved but rather it has increased (perhaps marginally).

This is to some extent a counterintuitive behaviour. The expected change is a reduction in the problem symptom as more efforts are invested in solving the problem but in reality, the results are the opposite. There are several factors shaping this behaviour but through the application of systems thinking we managed to understand a key feedback structure that was contributing to this dynamic.

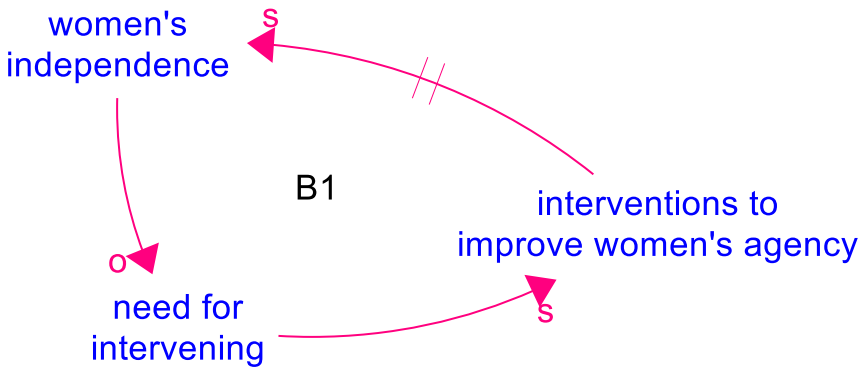


Figure 2 Intervention for improving Women's independence

The problem articulation strongly relied on the fact that women's independence and freedom were curtailed as a result of domestic violence and to solve this problem they needed to intervene to improve both their independence and freedom. Several interventions were identified and implemented through the program to improve these. The hypothesis was that if women's independence increased then it would lead to a better quality of life for women who are survivors of domestic violence. The above loop shows this hypothesis as a balancing feedback loop where the problem is fixed through the intervention over time (denoted by the time delay).

The above hypothesis did produce desired results in the short run where some success was seen in women's independence through interventions on education, providing livelihood and improving their financial literacy. However, in the medium-term to long-term, at an aggregate level, it did not produce the expected results. The instances of domestic violence did not reduce but perhaps increased. This is highlighted in the Behaviour Over Time Graph (BOTG) shown above. Hence, it was construed that there were other feedback loops at play which were creating counterforces negating the effects of the intervention.

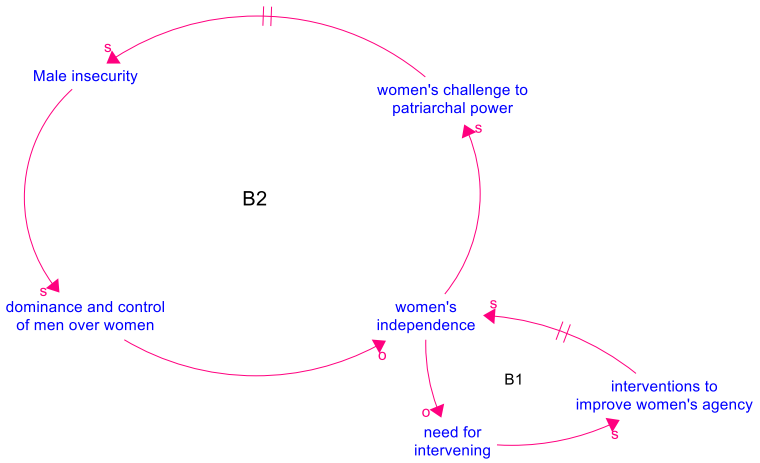


Figure 3 Pushback from Males creates more problems

The second loop was identified as the pushback received from Men in response to the challenge posed by women to the patriarchal powers in society and the domestic environment. As women's independence increased they started challenging the patriarchal power. This increased Men's insecurity and led to an increase in dominance and control by them over women, also increasing the instances of domestic violence. As they exercised more dominance and control the women's independence went down negating the gains of the interventions. As the indicator showed immediate success the projects continued to grow but over time as it did not show continued signs of success the agencies had to increase their efforts. All of this led to an increase in funding, number of projects and efforts for solving the problem.

The diagram above indicates that the problem articulation relied heavily on solving women's problems by increasing their independence and the program was thus focused on working predominantly with women who were survivors of domestic violence. After the systems thinking exercise it emerged that the way the intervention was implemented led to a pushback from the system causing an escalation. The intervention did not adequately cover an important stakeholder, the Men in the system who were causing the problems. Although some awareness generation and sensitization activities were carried out for Men it did not adequately focus on helping them acquire new behaviours, or change their belief systems. This was an Ahhaa moment for some participants and they acknowledged that developing more programs around men and including them in the process is important. If they continue to do things the same way then it would end up producing similar results and they doing more of the same is producing more counterproductive results. A sense of wisdom prevailed in the room as if we all had finally seen a light. Some people might have been aware of this at a subconscious level but may not have been able to articulate it the way it emerged through the systems thinking process. The participants did get clarity and insight on the reason for the counterintuitive results they were getting and some guidance on what they could do differently. The process of participatory systems thinking did its job of helping people gain insight into the system's structure that is producing the behaviour we observe in the real world.

Converting causal loops into a system dynamics simulation model

This exercise and the outcome it created helped us understand the value of the process and why it is important for organizations to apply systems thinking to improve their program design and

interventions. Converting feedback maps to system dynamics concept models helps generate scenarios and answer more specific questions (Sharma & Mathur, 2021). Hence, as a side exercise, we created a system dynamics concept model of the same loops for our internal purposes to test some of the learnings gained from these exercises. The model and the results it generated are presented below.

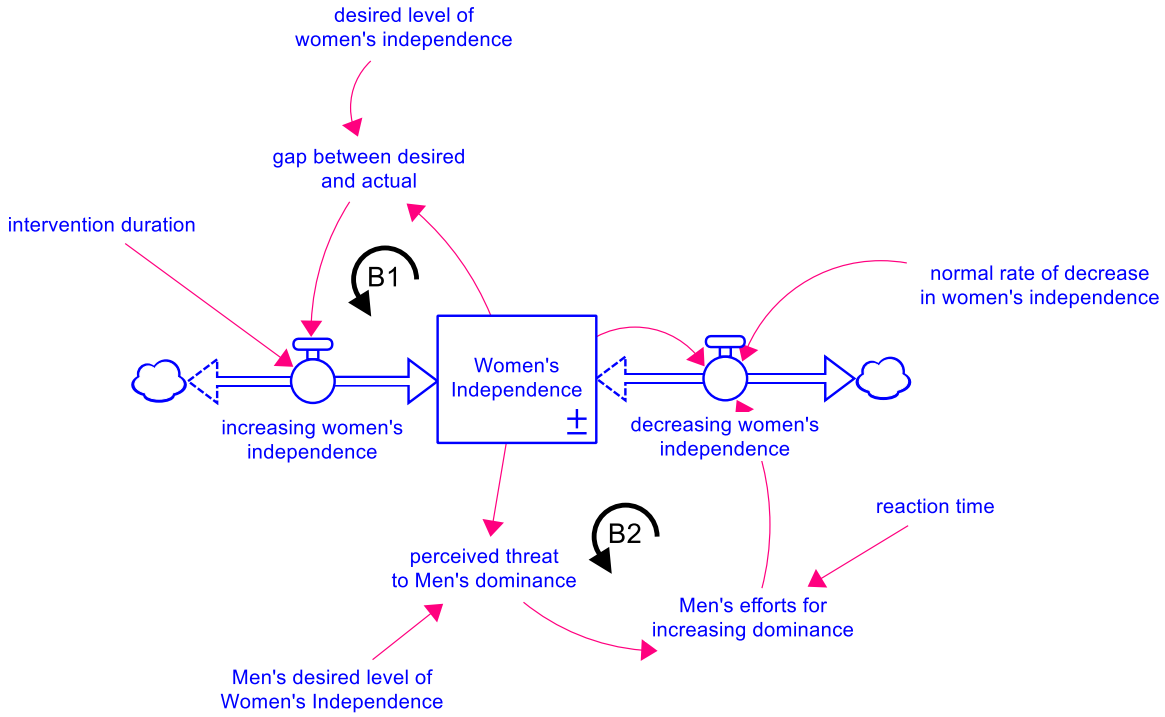


Figure 4 System Dynamics Concept Model of the competing loops

The above concept model has a single stock as the Level of Women's Independence (unitless). This stock increases through the interventions by the agency. As the current level of the stock is below the agency's desired level certain interventions are done through programs of working with survivors of domestic violence. The project duration is assumed to be of 4 years, which is somewhere close to a typical project cycle in the development sector. As the stock increases due to the intervention it creates a growing insecurity among Men. This is because there is a desired level of this stock in the minds of the Men in the society and domestic environments which according to them is the safe level for keeping women under control and allowing Men to continue their domination over them. Once the stock increases it challenges their control and power. Hence, after a time delay (assumed to be two years), Men respond by taking measures to reduce women's independence and increase their domination and control, sometimes also leading to instances of domestic violence. This then reduces the stock levels. This dynamic is shown in the first 10 years of the simulation run in Figure 5. Once the stock levels decrease it prompts a response from the agency which then again intervenes intending to increase the women's independence.

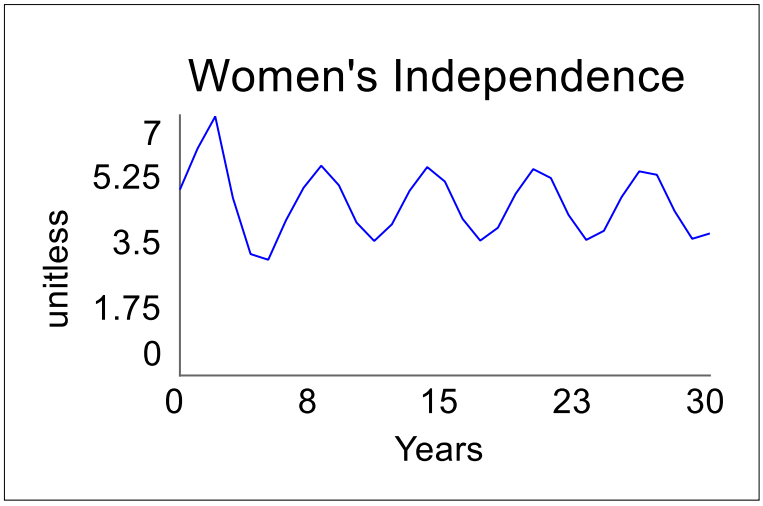


Figure 5 Changes in the Levels of Women's Independence

Over time the interaction between these two loops causes the stock to oscillate and the agency is never able to achieve its desired level of the stock even after years of intervention and numerous programs (including funding of these programs). The results generated are consistent with the systems thinking problem that surfaced in the workshops. With increased project funding and several projects the instances of domestic violence have not reduced but perhaps also increased. Although the system dynamics model does not explicitly model the instances of domestic violence it does indicate an associated increase through the actions taken by Men for regaining their power and control.

Sensitivity Runs

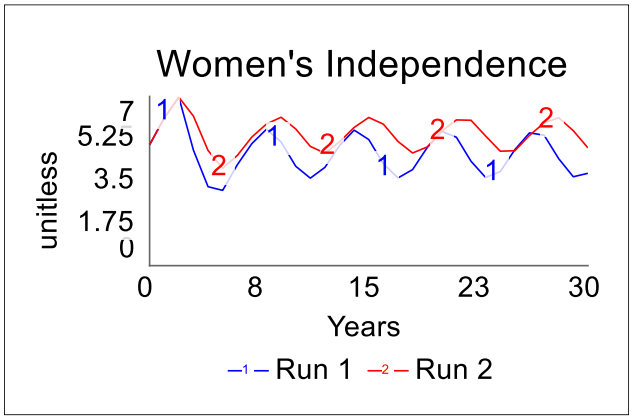


Figure 6 Working with Men to build acceptability towards Women's Independence

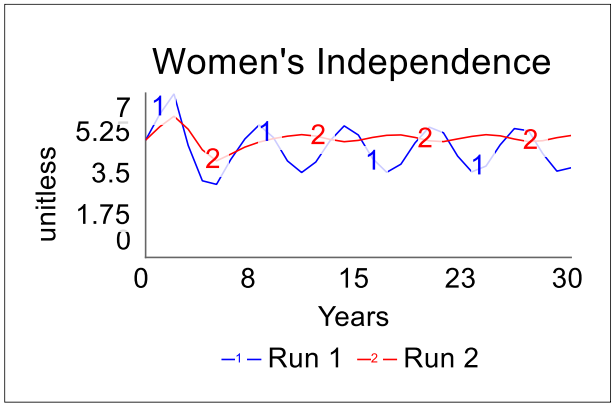


Figure 7 Agency lowering its own goal while also working with Men

The above two figures show the sensitivity runs by changing two exogenous variables.

1. Increasing the acceptability by Men towards Women's independence. This variable in the model is *Men's desired level of Women's Independence* which is increased by 25% to imply that Men have built more acceptability towards Women having independence. The parameter is increased by 25% to depict a social change in the real world where through a set of programs the Men have changed their outlook/worldview/belief system. This change results in a dampening of the oscillation and an increase in the level of women's independence. This increase is the average level of the stock over the simulation duration.
2. In addition to the above the agency also lowers its own goal of the desired level of women's independence. This variable in the model is *desired level of women's independence* which is reduced by 25% to imply that the agency has taken cognizance of the system that exists which has an opposite goal and any intervention is bound to receive a pushback from the system. Hence, moderating the goal could perhaps help in bridging the gap between the two competing goals thereby producing better outcomes. This change, in addition to the first parameter change, further produces stability in the levels of women's independence. Interestingly the stock level is lower than the level achieved in the first run but the instability is reduced thereby indicating that the pushback from the system is lower than before. This is important since it could also lead to a reduction in the probability of instances of domestic violence as a result of reduced pushback from Men.

Both the above runs indicate that if changes are made in the goals of the agency and the belief systems of Men, they together produce a higher impact on Women's independence. Thereby helping the system move towards the desired state. The above runs show us not just where to intervene in the system but also provide some direction for the changes required and more importantly why. The system dynamics model allows us to test these changes and go over the runs to contemplate the changes required and if they provide better results and under which context.

Comparing Systems Thinking and System Dynamics Results

Insight Areas	**Systems Thinking**	**System Dynamics**
Problem Articulation	Competing Goals	Competing Goals
Interventions Identified	Include Men in the Program	Moderate the Goals on Both Sides
Expected Results	Improvement in the Indicator	Reducing pushback and thereby instability/oscillations
Program Insight	Expand the Scope of the Program to include Men	The program's goals or expectations are also part of the problem
Intervention Point	Work with Men	Moderate goals by working with Men and also setting realistic program goals. Important to bridge the gap.

Figure 8 Table comparing insights gained from Systems Thinking and System Dynamics

Conclusions

Through systems thinking we collectively gained the insight that competing goals are the problem and that it is important to include Men in the program. However, it did not inform about the changes required in the intervention point like the need for moderation of the goal of the agency and also moderation of the goals of Men. The expected outcome or result also remained vague in the systems thinking process where the dominant expectation is still to see the indicator increase over time. However, through the results of the system dynamics concept model, the behaviour of the system became a little more explicitly clear and helped in visualizing what success could look like. In this case was to reduce the pushback received from men and thereby reduce instability.

Systems thinking was an important step in uncovering the system's structures which were producing the counterintuitive behaviour. It helped people come together and see the big picture, contribute their experience and also listen to each other's perspectives. The large causal map worked as a placeholder for putting all perspectives together and then thinking through the interconnections. The system dynamics model built upon the causal loop diagrams helped in answering more specific questions about where to intervene, how much, what results to expect and most importantly why. It allowed for doing sensitivity runs to understand the varying impacts and articulate why change would happen if that change is in the desired direction. Both methods together helped a) in getting people together to move from looking at parts to looking at wholes, b) listen to each other's perspectives and also reflect on their own, c) test their assumptions, d) test their newly identified areas of interventions and e) better articulate what changes are required in the system and what would success look like (as the simulation runs showed).

Applying either systems thinking or system dynamics could still provide useful insights for real-world problems. However, they by themselves are sometimes incomplete. Applying both together combines the science of modelling complicated and complex systems and the art of doing it with people who may not be systems scientists but have great experience engaging with complex systems. Participatory processes improve the ownership of the model and also create a sharper line of enquiry through more specific questions. System dynamics modelling then helps in answering these enlightened questions and moving towards policy design. Both together can help people gain wisdom and also test their newly gained wisdom for developing actionable intelligence to improve real-world systems.

Way Forward

Different methods provide utility at different stages of engagement or research. Systems thinking has the flexibility to be utilized at different stages of a modelling project. It can be used in the initial stage for doing problem articulation (Richardson 2015) or at a later stage for presenting key model feedback loops like it was most popularly used to present the WORLD3 model in the Limits to Growth publication (Meadows et al., 1972). Similarly, system dynamics simulation modelling could also provide answers at different stages. It could be used at an initial stage to set up a small concept model for the stakeholders to come to a consensus on the boundary conditions of the model and what are the key questions the model should answer (Richardson 2013) . Developing a concept model in the early stages of a modelling project has significant long-term benefits in terms of the acceptability of the outcomes or results. Both methods used together can amplify the impact and also expedite the process of modelling.

Some methods try to bridge the separation between systems thinking and system dynamics modeling like Agile SD (Warren 2015), Group Model Building (Vennix 1996) and community-based system dynamics (Hovmand 2014). Examples cited in literature from these methods should also be studied to identify good practices for merging the two methods. The first published use of causal loop diagrams in the system dynamics community was seen in the book Limits to Growth where the purpose of using CLDs was to communicate the key model structures as feedback loops to the general public (Meadows et al., 1972)(Johnson & Penn, 2022). The complicatedness of the system dynamics model necessitated the need to simplify the model structure through the use of qualitative feedback diagrams. Hence, the emergence of CLDs is rooted as a communications tool and not necessarily a modelling method in itself. Over time, due to the varying utilities it provided, CLDs have emerged as a tool for formally applying systems thinking methods to understand complicated and complex systems independent of system dynamics modeling. This paper tries to highlight some challenges associated with this separation.

Below are some other use cases where systems thinking maps could be converted to system dynamics models to further test the line of argument built in this paper.

1. Limits to growth of the Livestock population due to fodder available followed by an agency's intervention to cultivate more fodder. This typically leads to an expectation formation of increasing income or doubling a farmer's income. But in reality, it just increases the limit thereby also increasing the income but under a newfound limit. The result is not an exponential increase but a S-shaped growth that flattens out.
2. The famous chicken, egg and chicken crossing the road example is used to bring home the point of dynamics emerging through interactions of loops. A simulation model of the same could help better understand the situations producing the dynamics in addition to the assumptions that people make while plotting the BOTG of the stock of chicken. For example one of the responses often given is that the stock could oscillate (either diverge, converge or remain in a dynamics equilibrium) but the reasons for the oscillation are rooted in shifting loop dominance. A system dynamics model could help test this assumption.
3. Simulating system archetypes to test the dynamic behaviour they produce and what potential solutions exist to break out of the archetypes.

Annexure

Extreme Conditions Test

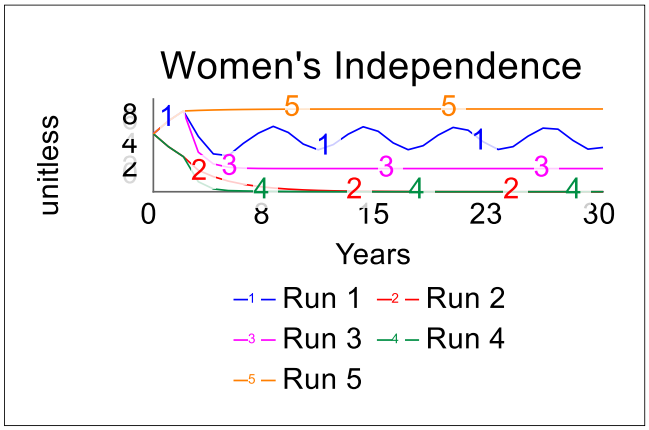


Figure 9 Extreme Condition Test Runs

Run 1 – Business as Usual: No change in initial conditions

Run 2 – No goal of the Agency: Making the agency's desired level of women's independence 0

Run 3 – No goal of Men: Making the Men's desired level of women's independence variable as 1

Run 4 – All goals reduced: Both the above parameters are set to 0 and 1 respectively

Run 5 – All goals are in sync: Both the above parameters are set to 10

Model Equations

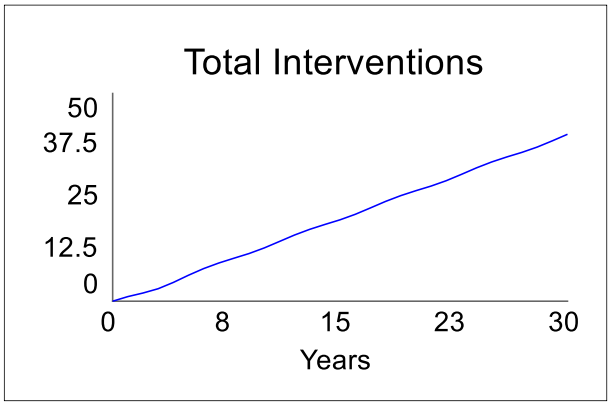
Total	Count	Including Array Elements
Variables	11	11
Stocks	1	1
Flows	2	2
Converters	8	8
Constants	5	5
Equations	5	5
Graphicals	1	1

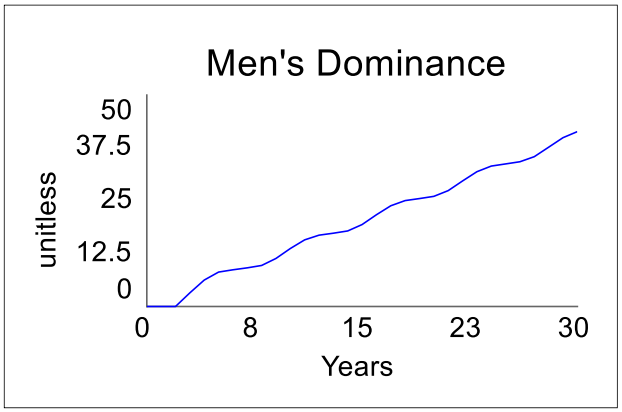
	Equation	Units
Women's_Independence(t)	Women's_Independence(t - dt) + (increasing_women's_independence - decreasing_women's_independence) * dt	unitless
decreasing_women's_independence	(Women's_Independence*normal_rate_of_decrease_in_women's_independence)*Men's_efforts_for_increasing_dominance	per year
increasing_women's_independence	gap_between_desired_and_actual/intervention_duration	per year
desired_level_of_women's_independence	10	unitless
gap_between_desired_and_actual	desired_level_of_women's_independence-Women's_Independence	unitless
intervention_duration	4	years
Men's_desired_level_of_Women's_Independence	10	unitless
Men's_efforts_for_increasing_dominance	DELAY(perceived_threat_to_Men's_dominance,reaction_time, 0)	unitless

normal_rate_of_decrease_in_women's_independence	.1	per year
perceived_threat_to_Men's_dominance	GRAPH(Women's_Independence/Men's_desired_level_of_Women's_Independence) Points: (1.000, 1.000), (1.100, 2.355), (1.200, 3.581), (1.300, 4.690), (1.400, 5.694), (1.500, 6.602), (1.600, 7.424), (1.700, 8.168), (1.800, 8.840), (1.900, 9.449), (2.000, 10.000)	unitless
reaction_time	2	years

Run Specs	
Start Time	0
Stop Time	30
DT	1/128
Fractional DT	True
Save Interval	1
Sim Duration	1.5
Time Units	Years
Pause Interval	0
Integration Method	Euler
Keep all variable results	True
Run By	Run
Calculate loop dominance information	True
Exhaustive Search Threshold	1000

Other Parameter Runs





References

Sterman, John. (2000) Business dynamics : systems thinking and modeling for a complex world. ISBN 0-07-231135-5

Sharma, K.; Mathur, M. Identifying Climate Adjacency for Enhancing Climate Action Using Systems Thinking and Modelling. Systems 2021, 9, 83. https://doi.org/10.3390/systems9040083

Barbrook-Johnson, P., Penn, A.S. (2022). Causal Loop Diagrams. In: Systems Mapping. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-031-01919-7_4

Richardson, G. P. System Dynamics, The Basic Elements of. Encyclopedia of Complexity and Systems Science. DOI 10.1007/978-3-642-27737-5_536-3. Springer Science+Business Media New York 2015

Alberghini L, Truant A, Santonicola S, Colavita G, Giaccone V. Microplastics in Fish and Fishery Products and Risks for Human Health: A Review. Int J Environ Res Public Health. 2022 Dec 31;20(1):789. doi: 10.3390/ijerph20010789. PMID: 36613111; PMCID: PMC9819327.

Warren, K. 2015. Agile SD: Fast, Effective, Reliable. Strategy Dynamics. https://strategydynamics.com/free/assets/Agile_Business_Modelling_with_System_Dynamics.pdf

Vennix, J. A. M.(1996): Group Model Building. Facilitating Team Learning Using System Dynamics.

Hovmand PS. *Community Based System Dynamics*. New York, NY: Springer; 2014.

Donella H. Meadows [and others]. The Limits to Growth; a Report for the Club of Rome's Project on the Predicament of Mankind. New York :Universe Books, 1972.

Richardson, G.P. (2013), Concept models in group model building. Syst. Dyn. Rev., 29: 42-55. https://doi.org/10.1002/sdr.1487