# Supplementary table 1 – Types of mainstreaming and instruments

|  |  |
| --- | --- |
| **Types of mainstreaming** | **References** |
| Process-based mainstreaming |  |
| Horizontal | (Nunan et al., 2012; Rauken et al., 2015; Wamsler and Pauleit, 2016) |
| Vertical | (Nunan et al., 2012; Rauken et al., 2015; Wamsler and Pauleit, 2016) |
| Normative | (Persson, 2004) |
| Procedural | (Eggenberger and Partidário, 2000; Persson, 2004) |
| Organizational | (Persson, 2004) |
| Substantive | (Eggenberger and Partidário, 2000) |
| Methodological | (Eggenberger and Partidário, 2000) |
| Institutional | (Eggenberger and Partidário, 2000) |
| Policy | (Eggenberger and Partidário, 2000; Wellstead and Stedman, 2015) |
| Outcome-based mainstreaming |  |
| Integrationist, incl. policy harmonization, coordination, institutionalization | (Gupta, 2010; Howlett and Saguin, 2018; Bleby and Foerster, 2023) |
| Transformative | (Gupta, 2010; Bleby and Foerster, 2023) |
| **Mainstreaming instruments** |  |
| Process strategies: add-on, programmatic, inter- and intra-organizational, regulatory, managerial, and directed approaches | (Wamsler and Pauleit, 2016) |
| Disruptive mechanisms: experimentation, scaling, translation, and anchoring mechanisms, incl. integration and learning | (Adams et al., 2024) |
| Governance mechanisms: regulatory, institutional, legal, policy | (Bleby and Foerster, 2023) |
| Capacity/Knowledge | (New et al., 2022) |
| Financial | (New et al., 2022) |

# References

Adams, C., Frantzeskaki, N., and Moglia, M. (2023). Mainstreaming nature-based solutions in cities: A systematic literature review and a proposal for facilitating urban transitions. *Land Use Policy* 130, 106661. doi: 10.1016/j.landusepol.2023.106661

Adams, C., Moglia, M., and Frantzeskaki, N. (2024). Realising transformative agendas in cities through mainstreaming urban nature-based solutions. *Urban Forestry & Urban Greening* 91, 128160. doi: 10.1016/j.ufug.2023.128160

Adelle, C., and Russel, D. (2013). Climate Policy Integration: a Case of Déjà Vu? *Environmental Policy and Governance* 23, 1–12. doi: 10.1002/eet.1601

Ahenkan, A., Chutab, D. N., and Boon, E. K. (2021). Mainstreaming climate change adaptation into pro-poor development initiatives: evidence from local economic development programmes in Ghana. *Climate and Development* 13, 603–615. doi: 10.1080/17565529.2020.1844611

Aleksandrova, M. (2020). Principles and considerations for mainstreaming climate change risk into national social protection frameworks in developing countries. *Climate and Development* 12, 511–520. doi: 10.1080/17565529.2019.1642180

Atanga, R. A., Inkoom, D. K. B., and Derbile, E. K. (2017). Mainstreaming Climate Change Adaptation into Development Planning in Ghana. *Ghana J. Dev. Stud.* 14, 209. doi: 10.4314/gjds.v14i2.11

Ayers, J. M., Huq, S., Faisal, A. M., and Hussain, S. T. (2014). Mainstreaming climate change adaptation into development: a case study of Bangladesh. *WIREs Climate Change* 5, 37–51. doi: 10.1002/wcc.226

Bertana, A., and Blanton, N. (2023). Climate change adaptation, gender, and mainstreaming: the role of gender in Fiji’s relocation initiative. *Climate and Development* 15, 60–68. doi: 10.1080/17565529.2022.2055524

Bleby, A., and Foerster, A. (2023). A Conceptual Model for Climate Change Mainstreaming in Government. *Transnational Environmental Law* 12, 623–648. doi: 10.1017/S2047102523000158

Boezeman, D., and De Vries, T. (2019). Climate proofing social housing in the Netherlands: toward mainstreaming? *Journal of Environmental Planning and Management* 62, 1446–1464. doi: 10.1080/09640568.2018.1510768

Braunschweiger, D., and Pütz, M. (2021). Climate adaptation in practice: How mainstreaming strategies matter for policy integration. *Environmental Policy and Governance* 31, 361–373. doi: 10.1002/eet.1936

Burns, C., Flood, S., and O’Dwyer, B. (2022). “Mainstreaming Climate Change Adaptation into Planning and Development: A Case Study in Northern Ireland,” in *Creating Resilient Futures: Integrating Disaster Risk Reduction, Sustainable Development Goals and Climate Change Adaptation Agendas*, eds. S. Flood, Y. Jerez Columbié, M. Le Tissier, and B. O’Dwyer (Cham: Springer International Publishing), 129–147. doi: 10.1007/978-3-030-80791-7\_7

Candel, J. J. L. (2021). The expediency of policy integration. *Policy Studies* 42, 346–361. doi: 10.1080/01442872.2019.1634191

Chakrabarti, P. G. D. (2017). *Mainstreaming Disaster Risk Reduction for Sustainable Development: A Guidebook for the Asia Pacific*. Available at: https://www.unescap.org/sites/default/d8files/knowledge-products/publication\_WEBdrr02\_Mainstreaming.pdf (Accessed May 9, 2025).

Colven, E. (2017). Understanding the Allure of Big Infrastructure: Jakarta’s Great Garuda Sea Wall Project. *Water Alternatives* 10, 250–264.

Cuevas, S. C. (2016a). Examining the challenges in mainstreaming climate change adaptation into local land-use planning: The case of Albay, Philippines. The University of Queensland. doi: 10.14264/uql.2016.161

Cuevas, S. C. (2016b). The interconnected nature of the challenges in mainstreaming climate change adaptation: evidence from local land use planning. *Climatic Change* 136, 661–676. doi: 10.1007/s10584-016-1625-1

Cuevas, S. C. (2017). Institutional dimensions of climate change adaptation: insights from the Philippines. *Climate Policy* 18, 499–511. doi: 10.1080/14693062.2017.1314245

Dalal-Clayton, D. B., and Bass, S. (2009). *The challenges of environmental mainstreaming: experience of integrating environment into development institutions and decisions*. London: International Institute for Environment and Development.

Dellmuth, L. M., and Gustafsson, M.-T. (2021). Global adaptation governance: how intergovernmental organizations mainstream climate change adaptation. *Climate Policy* 21, 868–883. doi: 10.1080/14693062.2021.1927661

Dodman, D., Hayward, B., Pelling, M., Castan Broto, V., Chow, W., Chu, E., et al. (2022). “Cities, Settlements and Key Infrastructure,” in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 907–1040. doi: 10.1017/9781009325844.008

Doshi, D., and Garschagen, M. (2024). Actor-specific adaptation objectives shape perceived roles and responsibilities: lessons from Mumbai’s flood risk reduction and general considerations. *Reg Environ Change* 24, 164. doi: 10.1007/s10113-024-02315-3

Du, J., Greiving, S., and Yap, D. L. T. (2022). Informal Settlement Resilience Upgrading-Approaches and Applications from a Cross-Country Perspective in Three Selected Metropolitan Regions of Southeast Asia. *Sustainability* 14, 8985. doi: 10.3390/su14158985

Duy, P. N., Chapman, L., Tight, M., Linh, P. N., and Thuong, L. V. (2018). Increasing vulnerability to floods in new development areas: evidence from Ho Chi Minh City. *IJCCSM* 10, 197–212. doi: 10.1108/IJCCSM-12-2016-0169

Eggenberger, M., and Partidário, M. R. (2000). Development of a framework to assist the integration of environmental, social and economic issues in spatial planning. *Impact Assessment and Project Appraisal* 18, 201–207. doi: 10.3152/147154600781767448

Farrell, L. A. (Leanne A. (2010). Mainstreaming climate change adaptation into urban development : lessons from two South African cities. Massachusetts Institute of Technology. Available at: https://dspace.mit.edu/handle/1721.1/59569 (Accessed November 6, 2023).

Fatemi, M. N., Okyere, S. A., Diko, S. K., and Kita, M. (2020). Multi-Level Climate Governance in Bangladesh via Climate Change Mainstreaming: Lessons for Local Climate Action in Dhaka City. *Urban Science* 4, 24. doi: 10.3390/urbansci4020024

Friend, R., Jarvie, J., Reed, S. O., Sutarto, R., Thinphanga, P., and Toan, V. C. (2014). Mainstreaming urban climate resilience into policy and planning; reflections from Asia. *Urban Climate* 7, 6–19. doi: 10.1016/j.uclim.2013.08.001

Gabriel, A. G., Santiago, P. N. M., and Casimiro, R. R. (2021). Mainstreaming Disaster Risk Reduction and Climate Change Adaptation in Comprehensive Development Planning of the Cities in Nueva Ecija in the Philippines. *Int J Disaster Risk Sci* 12, 367–380. doi: 10.1007/s13753-021-00351-9

García Sánchez, F. (2022). “Mainstreaming Adaptation into Urban Planning: Projects and Changes in Regulatory Frameworks for Resilient Cities,” in *Business and Policy Solutions to Climate Change: From Mitigation to Adaptation*, eds. T. Walker, S. Wendt, S. Goubran, and T. Schwartz (Cham: Springer International Publishing), 265–289. doi: 10.1007/978-3-030-86803-1\_12

García Sánchez, F., Solecki, W. D., and Ribalaygua Batalla, C. (2018). Climate change adaptation in Europe and the United States: A comparative approach to urban green spaces in Bilbao and New York City. *Land Use Policy* 79, 164–173. doi: 10.1016/j.landusepol.2018.08.010

Garschagen, M., Surtiari, G. A. K., and Harb, M. (2018). Is Jakarta’s New Flood Risk Reduction Strategy Transformational? *Sustainability* 10, 2934. doi: 10.3390/su10082934

Gupta, J. (2010). “Mainstreaming climate change: a theoretical exploration,” in *Mainstreaming Climate Change in Development Cooperation*, ed. J. Gupta (Cambridge University Press), 67–96. doi: 10.1017/CBO9780511712067.004

Hanna, C., Cretney, R., and White, I. (2022). Re-Imagining Relationships with Space, Place, and Property: The Story of Mainstreaming Managed Retreats in Aotearoa-New Zealand. *Planning Theory & Practice* 23, 681–702. doi: 10.1080/14649357.2022.2141845

Howlett, M. P., and Saguin, K. (2018). Policy Capacity for Policy Integration: Implications for the Sustainable Development Goals. *SSRN Journal*. doi: 10.2139/ssrn.3157448

Khailani, D. K., and Perera, R. (2013). Mainstreaming disaster resilience attributes in local development plans for the adaptation to climate change induced flooding: A study based on the local plan of Shah Alam City, Malaysia. *Land Use Policy* 30, 615–627. doi: 10.1016/j.landusepol.2012.05.003

Koch, F. (2018). Mainstreaming adaptation: a content analysis of political agendas in Colombian cities. *Climate and Development* 10, 179–192. doi: 10.1080/17565529.2016.1223592

Lasco, R. D., Pulhin, F. B., Jaranilla-Sanchez, P. A., Delfino, R. J. P., Gerpacio, R., and Garcia, K. (2009). Mainstreaming adaptation in developing countries: The case of the Philippines. *Climate and Development* 1, 130–146. doi: 10.3763/cdev.2009.0009

Lauer, H., Chaves, C. M. C., Lorenzo, E., Islam, S., and Birkmann, J. (2024). Risk reduction through managed retreat? Investigating enabling conditions and assessing resettlement effects on community resilience in Metro Manila. *Natural Hazards and Earth System Sciences* 24, 2243–2261. doi: 10.5194/nhess-24-2243-2024

Linke, S., Erlwein, S., van Lierop, M., Fakirova, E., Pauleit, S., and Lang, W. (2022). Climate Change Adaption between Governance and Government—Collaborative Arrangements in the City of Munich. *Land* 11, 1818. doi: 10.3390/land11101818

Lyles, W., Berke, P., and Overstreet, K. H. (2018). Where to begin municipal climate adaptation planning? Evaluating two local choices. *Journal of Environmental Planning and Management* 61, 1994–2014. doi: 10.1080/09640568.2017.1379958

Macchi, S., and Ricci, L. (2016). “15. Climate Change Adaptation Through Urban Planning: a Proposed Approach for Dar Es Salaam, Tanzania,” in *Planning to cope with tropical and subtropical climate change*, (De Gruyter Open), 267–289. doi: 10.1515/9783110480795-016

Metzger, J., Carlsson Kanyama, A., Wikman-Svahn, P., Mossberg Sonnek, K., Carstens, C., Wester, M., et al. (2021). The flexibility gamble: challenges for mainstreaming flexible approaches to climate change adaptation. *Journal of Environmental Policy & Planning* 23, 543–558. doi: 10.1080/1523908X.2021.1893160

Mogelgaard, K., Dinshaw, A., Ginoya, N., Gutiérrez, M., Preethan, P., and Waslander, J. (2018). From Planning to Action: Mainstreaming Climate Change Adaptation into Development. Washington, D.C.: World Resources Institute. Available at: https://www.wri.org/publication/climate-planning-to-action

Mugari, E., and Nethengwe, N. S. (2022). Mainstreaming Ecosystem-Based Disaster Risk Reduction: Towards a Sustainable and Just Transition in Local Development Planning in Rural South Africa. *Sustainability* 14, 12368. doi: 10.3390/su141912368

Nassef, Y. (2012). “Mainstreaming Climate Change Adaptation into Development Planning,” in *Climate Change in Asia and the Pacific: How Can Countries Adapt?*, (B-42, Panchsheel Enclave, New Delhi 110 017 India: SAGE Publications India Pvt Ltd), 328–337. doi: 10.4135/9788132114000.n26

New, M., Reckien, R., Viner, D., Adler, C., Cheong, S.-M., Conde, C., et al. (2022). “Decision-Making Options for Managing Risk,” in *Climate Change 2022: Impacts, Adaptation and Vulnerability*, eds. H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press), 2539–2654. doi: 10.1017/9781009325844

Newman, P. (2020). Cool planning: How urban planning can mainstream responses to climate change. *Cities* 103, 102651. doi: 10.1016/j.cities.2020.102651

Nunan, F., Campbell, A., and Foster, E. (2012). Environmental Mainstreaming: The Organisational Challenges of Policy Integration: Public Administration & Development. *Public Administration & Development* 32, 262–277. doi: 10.1002/pad.1624

Olhoff, A., and Schaer, C. (2010). Screening Tools and Guidelines to Support the Mainstreaming of Climate Change Adaptation into Development Assistance – A Stocktaking Report. New York: UNDP. Available at: https://www.sprep.org/att/IRC/eCOPIES/Global/391.pdf

Palutikof, J. P., Street, R. B., and Gardiner, E. P. (2019). Looking to the future: guidelines for decision support as adaptation practice matures. *Climatic Change* 153, 643–655. doi: 10.1007/s10584-019-02404-x

Pasquini, L., Ziervogel, G., Cowling, R. M., and Shearing, C. (2015). What enables local governments to mainstream climate change adaptation? Lessons learned from two municipal case studies in the Western Cape, South Africa. *Climate and Development* 7, 60–70. doi: 10.1080/17565529.2014.886994

Persson, K. (2004). Environmental Policy Integration: An Introduction. Stockholm: Stockholm Environment Institute (SEI. Available at: https://mediamanager.sei.org/documents/Publications/Policy-institutions/EPI.pdf

Pieterse, A., Du Toit, J., and Van Niekerk, W. (2021). Climate change adaptation mainstreaming in the planning instruments of two South African local municipalities. *Development Southern Africa* 38, 493–508. doi: 10.1080/0376835X.2020.1760790

Rauken, T., Mydske, P. K., and Winsvold, M. (2015). Mainstreaming climate change adaptation at the local level. *Local Environment* 20, 408–423. doi: 10.1080/13549839.2014.880412

Reckien, D., Salvia, M., Pietrapertosa, F., Simoes, S. G., Olazabal, M., De Gregorio Hurtado, S., et al. (2019). Dedicated versus mainstreaming approaches in local climate plans in Europe. *Renewable and Sustainable Energy Reviews* 112, 948–959. doi: 10.1016/j.rser.2019.05.014

Rogers, N. J. L., Adams, V. M., and Byrne, J. A. (2023). Factors affecting the mainstreaming of climate change adaptation in municipal policy and practice: a systematic review. *Climate Policy* 23, 1327–1344. doi: 10.1080/14693062.2023.2208098

Runhaar, H., Wilk, B., Persson, Å., Uittenbroek, C., and Wamsler, C. (2018). Mainstreaming climate adaptation: taking stock about “what works” from empirical research worldwide. *Regional Environmental Change* 18, 1201–1210. doi: 10.1007/s10113-017-1259-5

Saito, N. (2013). Mainstreaming climate change adaptation in least developed countries in South and Southeast Asia. *Mitig Adapt Strateg Glob Change* 18, 825–849. doi: 10.1007/s11027-012-9392-4

Schipper, E. L., Revi, A., Preston, B. L., Carr, E. R., Eriksen, S. H., Fernández-Carril, L. R., et al. (2022). “Climate Resilient Development Pathways,” in *Climate Change 2022: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, M. Craig, et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press). doi: 10.1017/9781009325844

Sen, J., and Dhote, M. (2023). “Mainstreaming Biodiversity in Urban Habitats for Enhancing Ecosystem Services: A Conceptual Framework,” in *Climate Crisis: Adaptive Approaches and Sustainability*, eds. U. Chatterjee, R. Shaw, S. Kumar, A. D. Raj, and S. Das (Cham: Springer Nature Switzerland), 349–368. doi: 10.1007/978-3-031-44397-8\_19

Storch, H., and Downes, N. K. (2011). A scenario-based approach to assess Ho Chi Minh City’s urban development strategies against the impact of climate change. *Cities* 28, 517–526. doi: 10.1016/j.cities.2011.07.002

Taylor, H., Reid, J., Rinschede, T., Sett, D., Fee, L., Cea, L., et al. (2018). Climate Change and National Urban Policies in Asia and the Pacific: A Regional Guide for Integrating Climate Change Concerns into urban-related Policy, Legislative, Financial and Institutional Frameworks. Nairobi, Kenya and Bangkok, Thailand: United Nations Human Settlements Programme (UN-HABITAT) and United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP).

Tellman, B., Sullivan, J. A., Kuhn, C., Kettner, A. J., Doyle, C. S., Brakenridge, G. R., et al. (2021). Satellite imaging reveals increased proportion of population exposed to floods. *Nature* 596, 80–86. doi: 10.1038/s41586-021-03695-w

ten Brinke, N., Kruijf, J. V., Volker, L., and Prins, N. (2022). Mainstreaming climate adaptation into urban development projects in the Netherlands: private sector drivers and municipal policy instruments. *Climate Policy* 22, 1155–1168. doi: 10.1080/14693062.2022.2111293

Tosun, J., and Lang, A. (2017). Policy integration: mapping the different concepts. *Policy Studies* 38, 553–570. doi: 10.1080/01442872.2017.1339239

Uittenbroek, C. J. (2016). From Policy Document to Implementation: Organizational Routines as Possible Barriers to Mainstreaming Climate Adaptation. *Journal of Environmental Policy & Planning* 18, 161–176. doi: 10.1080/1523908X.2015.1065717

Uittenbroek, C. J., Janssen-Jansen, L. B., and Runhaar, H. A. C. (2013). Mainstreaming climate adaptation into urban planning: overcoming barriers, seizing opportunities and evaluating the results in two Dutch case studies. *Reg Environ Change* 13, 399–411. doi: 10.1007/s10113-012-0348-8

UNDP-UNEP Poverty-Environment Initiative (2011). Guide Mainstreaming Climate Change Adaptation into Development Planning: A Guide for Practitioners.

Wade, M. (2019). Hyper‐planning Jakarta: The *Great Garuda* and planning the global spectacle. *Singap J Trop Geogr* 40, 158–172. doi: 10.1111/sjtg.12262

Wamsler, C., and Osberg, G. (2022). Transformative climate policy mainstreaming – engaging the political and the personal. *Glob. Sustain.* 5, e13. doi: 10.1017/sus.2022.11

Wamsler, C., and Pauleit, S. (2016). Making headway in climate policy mainstreaming and ecosystem-based adaptation: two pioneering countries, different pathways, one goal. *Climatic Change* 137, 71–87. doi: 10.1007/s10584-016-1660-y

Wannewitz, M., Ajibade, I., Mach, K. J., Magnan, A., Petzold, J., Reckien, D., et al. (2024). Progress and gaps in climate change adaptation in coastal cities across the globe. *Nat Cities* 1, 610–619. doi: 10.1038/s44284-024-00106-9

Wellstead, A., and Stedman, R. (2015). Mainstreaming and beyond: Policy capacity and climate change decision-making. *Michigan Journal of Sustainability* 3. doi: 10.3998/mjs.12333712.0003.003

Widmer, A. (2018). Mainstreaming climate adaptation in Switzerland: How the national adaptation strategy is implemented differently across sectors. *Environmental Science & Policy* 82, 71–78. doi: 10.1016/j.envsci.2018.01.007